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THE VISUAL BRILLIANCY OF THE PLANETS. A NEW FORMULA.

ROBERDEAU BUCHANAN.

FOR POPULAR ASTRONOMY.

The brilliancy of the three inner planets as given in the *Nautical Almanac* does not show their relative brightness as seen by the naked eye, on account of their different powers of reflecting light. The formula does not take account of this but regards the *Albedo* of planets as unity, in other words, that they reflect all the light they receive from the Sun.

The formulae are founded upon the laws of the intensity of light, that it varies directly as the area of the reflecting surface and inversely as the square of the distance. The area of the reflecting surface is then regarded as the light.

In the plane triangle S E P, let S be the Sun, E the Earth, and P the planet. Around P describe a small circle to represent the planet's sphere. Draw a diameter perpendicular to P S which will show the illuminated hemisphere; perpendicular to P E draw another diameter which will show the hemisphere turned towards the Earth, consisting of the visible portion and dark limb which is invisible to the eye. Let i be the angle E P S at the planet. This is also the angle between the two diameters.

Let s be the semi-diameter of the planets in seconds seen from the eye.

p the distance of the planet from the Earth.

r its distance from the Sun.

R the distance of the Earth from the Sun.

Subscripts denote mean values which are constants and the standards.

R is not needed in the present discussion but occurs in formulae for computing the other elements of the Disk given in the *Nautical Almanac*.

The visible extremity of the diameter perpendicular to P S is one point of the terminator of the hemisphere. This is a great

circle of the planet and seen obliquely by the eye is consequently an ellipse. Regarding the planet's surface as a flat disk the illuminated portion is a semi-circle plus a semi-ellipse. The radius of the circle is s the planet's semi-diameter. And projecting the half of the terminator diameter upon the diameter perpendicular to P E it is $s \cos i$ which is the conjugate axis of the ellipse, while s is its transverse axis; hence the versed sine of the illuminated portion is

$$k = \frac{s + s \cos i}{2s} = \frac{1 + \cos i}{2} = \cos^2 \tfrac{1}{2} i \qquad (1)$$

This quantity is also the ratio of the area of the illuminated portion to the area of the whole disk—a curious property of the ellipse and circle that a line—a linear quantity, should be the ratio of two areas, which depend upon squares.

To find the brilliancy consider a comparison disk at distance p from the eye (the distance of the planet) and subtending an angle of one second (1″) at this distance.

First find the semi-diameter u of this disk at distance r_0, which is directly as the areas and inversely as the squares of the distances

$$\frac{\pi u^2}{\pi (1'')^2} = \frac{p^2}{r_0^2} \qquad u^2 = \frac{p^2}{r_0^2} \qquad (2)$$

It is the same whether seen from the eye or the Sun, or anywhere else, at these distances. This quantity seen from the Sun will be the relative size of the 1″ disk seen from the Earth, and u will moreover be distant from the Sun equal to the planet's mean distance, it will therefore be "illuminated as the mean disk is illuminated."

The light of this disk reflected to the Earth at distance p will be inversely as the square of this distance. And if only a portion of the planet's disk k reflects light, this disk should reflect in the same proportion, hence we have the unit of Light or of L

$$U^2 = \frac{p^2}{r_0^2} \cdot \frac{k}{p^2} = \frac{k}{r_0^2} \qquad (3)$$

which is reflected from the comparison disk to the Earth.

The planet's mean semi-diameter s_0 at mean distance p_0 are the same, whether measured from the Earth or Sun. Let S be the semi-diameter at distance r, then according to the previous proportions

$$\frac{S^2}{s_0^2} = \frac{p_0^2}{r^2} \qquad S^2 = \frac{s_0^2 p_0^2}{r^2} \qquad (4)$$

This light reflected to the Earth distance p is inversely as the

square of the distance, and as only a portion of the disk k reflects light, we have

$$s^2 = \frac{s_0^2\, p_0^2\, k}{r^2\, p^2} \qquad (5)$$

This is the amount of light received at the Earth but is not the brilliancy, which is the *number of units of light*, and dividing by equation (3) we have the brilliancy *

$$L = \frac{s_0^2\, p_0^2\, r_0^2}{r^2\, p^2} = \left(\frac{s_0\, p_0\, r_0}{r\, p}\right)^2 \qquad (6)$$

This formula differs from that heretofore employed, by the omission of k and the insertion of the new factor r_0^2 in the numerator,—the planet's mean distance from the Sun.

The Albedo of the several planets may be found in Young's Astronomy where Zöllner is given as the authority. L is computed by formula (6).

VISUAL BRILLIANCY.

Planet.	L.	Albedo.	Visual Brilliancy.	
Mercury	15.1	0.13	2.0	1907 Feb. 24
Venus	426.6	0.50	213.3	1907 Jan. 5
Mars	202.0	0.26	52.5	1909 Sept. 18
Mars	46.5	0.26	12.1	1901 Feb. 20
Jupiter	351.9	0.62	218.2	At opposition
Saturn	76.9	0.52	40.0	At opposition
Uranus	2.82	0.64	1.80	Mean values
Neptune	1.64	0.46	0.75	Mean values

The Albedo of white paper, 070.

Mars at the opposition 1909, September 18, will be near its perihelion and close to the Earth. In 1901 February 20 it was in opposition four days from its aphelion passage, and distant from the Earth; the above date was between these two times.

* The preparation of the present article led to the discovery of a great discrepancy in the resulting values for all the planets. The writer had noticed this about ten years before; but now this article could not be written until the trouble was discovered. It was found to be an obscure mistake in the definition of the brilliancy given on the pages of the disks in the *Nautical Almanac* where the disk of 1″ radius is defined to be "situated at distance unity from the Sun and illuminated . . . as the mean disk of the planet is illuminated." This is an impossible definition because no planet but the Earth is at unit distance from the Sun so that this disk cannot be illuminated "as the mean disk of the planet is illuminated." The 1″ disk should be described as situated "at the planet's mean distance from the Sun." This discrepancy originated a year before the writer entered the *Nautical Almanac* Office. Mercury and Venus have been given wrongly, as to the brilliancy, in the *Nautical Almanac* since 1882, and Mars since 1901, to 1908. The formula heretofore used for the brilliancy is equation (5) above given.

RESEARCHES AS TO THE IDENTITY OF THE PERIODIC COMET OF 1889-1896-1903 (Brooks) WITH THE PERIODIC COMET OF 1770 (Lexell).*

CHARLES LANE POOR.

Introduction.

1. The comet was discovered by William R. Brooks, at Geneva, New York, July 6, 1889, and was observed until January, 1891. It was a faint telescopic object, never visible to the naked eye, and showing no striking physical characteristics; but of interest on account of the orbit it described and of the many problems in astro-mechanics which have arisen in the attempt to trace its past history. After a very few observations had been made, it was recognized as a periodic comet, travelling in an orbit of about seven years, and a very interesting member of Jupiter's so-called family. Chandler † was the first to investigate its history and show that its orbit had been changed radically by a close approach to Jupiter in 1886; that before that time the comet was moving in an entirely different orbit from that in which it has since moved. The interest in the problem was still further increased by the statement of Chandler that the comet of 1889 was probably identical with the lost comet of 1770 (Lexell). Chandler's results, however, depended upon observations extending over a period of three months only, and the perturbations during the years 1886 to 1889 were neglected. In this paper Chandler gave the period of the comet previous to 1886 as 26.9 years, and upon the substantial correctness of these figures depended his conclusions as to the identity with Lexell's comet.

2. Lexell's comet was first seen by Messier on the night of June 14-15, 1770. He at first thought it to be a part of the nebula in the constellation Sagittarius but after a few nights he recognized its cometary character. At this time it was faint and invisible without the aid of a telescope, and appeared as a nebulosity about 5′ 23″ in diameter. On June 21, however, it became visible to the unaided eye, and three days later was as bright as a second magnitude star. It was now seen to have an ill defined head, or nucleus, of about 80″ diameter and a tail which reached its greatest length on July 1, when it extended 2° 23′. On July 4 the comet disappeared in the rays of the Sun, not

* From *Contributions from the Observatory of Columbia University* we reprint here the Introduction and Conclusions given in his exhaustive paper bearing title, as above. [Editors.]

† "The Action of Jupiter in 1886 upon Comet *d*, 1889, and the Identity of the latter with Lexell's Comet of 1770," *Astro. Jour.*, 205, p. 100.

to reappear until August 4, after which it could be seen by the unaided eye until the 26th of August and in the telescope until Oct. 3, when its distance from the Earth and Sun became so great as to render it invisible with the instruments of that day.

Parabolic elements were calculated by Pingrè, Lambert and others. These, however, did not satisfy all the observations and it remained for Lexell to prove that the comet was travelling in an elliptic orbit of 5.6 years' period. Lexell further showed, in answer to various objections to the theory of elliptic motion, that in May, 1767, the comet had passed very close to Jupiter and that then its orbit had probably been greatly changed—changed sufficiently to render it visible in 1770. He further predicted a second approach of the comet to Jupiter in August, 1779, and stated that the occurrence might prevent the return of the comet in 1781 or 1782. The comet was sought vainly in those years, and has never been observed since.

In 1844 LeVerrier* presented to the *Académie des Sciences* his researches upon the motion of this comet and upon the character of the disturbances by Jupiter in 1779. This paper is a complete treatise upon the subject, discussing every phase of the matter in a most thorough manner. Unfortunately, however, LeVerrier found that the old observations were so crude that a definitive determination of the orbit was impossible. A comparison of the observed and computed places showed errors in the original observations amounting in many instances to ten or even fifteen minutes of arc. Unable to determine the exact elements of the orbit, LeVerrier expressed the elements which best represented the motion of the comet in terms of an unknown and indeterminate quantity, μ. This quantity is carried through all the calculations and the paper concludes with tables showing a number of possible orbits of the comet after its great disturbance by Jupiter in 1779.

3. Lexell's comet underwent its notable disturbance in August, 1779, and, moreover, this disturbance took place in that part of Jupiter's orbit in which the Brooks comet suffered its change of elements in 1886. Between these two appulses there intervened a period of 107 years, which must be accurately accounted for in order to establish the identity of these two bodies. That is, during this interval the comet must have made two, three or four complete revolutions about the Sun, and its period, therefore, must have been one-half, a third or some aliquot part

* "Théorie de la Comète Periodique de 1770," *Annals de l' Observatoire de Paris*, Tom. 111, p. 203.

of 107 years. Chandler, in the above mentioned paper,* found that the period of the Brooks comet previous to 1886 was 26.9 years, very approximately one quarter of the 107 years to be accounted for. The possibility of the comet having made three revolutions during this period can be eliminated, according to Chandler, as this would have brought the comet and Jupiter together in 1815 and 1850, at which times the perturbations would have been enormous. The interval can hardly be accounted for upon any other supposition than that of four revolutions of the comet being equal to nine of Jupiter's.

A comparison of the elements of Lexell's comet, subsequent to its disturbance in 1779, as given by LeVerrier, with those of the Brooks comet previous to 1886, as given by Chandler, show a striking likeness. The longitude of the node is nearly the same for both, 175° for Lexell against 177° for Brooks; the inclinations differ by less than 4° and the eccentricities are not far apart. Again, the heliocentric longitudes, within which the attraction of the Sun was overborne by the influence of Jupiter are nearly the same for both comets. Taking all these points of resemblance into consideration and assuming the substantial correctness of the period (26.9 years) he deduced, Chandler concluded that there is "an overwhelmingly strong presumption in favor of the identity of these two comets."

4. The question of identity was investigated in an entirely different manner by Schulhof,† who made use of a criterion formulated by Tisserand. By an investigation of the path of a comet through a planet's "sphere of activity," Tisserand derived a function, n, of the comet's elements and of those of the disturbing planet, which remains practically unaltered, however great the change in the individual elements. The action of Jupiter, for example, even repeated at several very close appulses, can cause but a very slight change in the numerical value of this function. Schulhof found that the n's for Lexell's and for Brooks' comets differed, and that the comets, therefore, could not be identical.

This criterion, however, only holds if the comet has been disturbed by a single planet, and in a later paper‡ Schulhof discussed the possibility of the identity of the two comets, assuming that there had been disturbances by both Jupiter and Saturn. By assuming the identity of the two comets, he was able to deduce, by means of the criterion, the most probable orbit of the body be-

* *Astro. Jour.*, No. 205.

† *Bulletin Astronomique*, November, 1889.

‡ *Bulletin Astronomique* December, 1889.

tween 1779 and 1886. He thus found that, if these bodies are one and the same, its period must have been about 32 years from 1779 to 1849, at which time it passed close to Saturn, suffered large disturbances and had its period increased to about 42 years. Thus the comet made three revolutions in the 107 years to be accounted for, but three revolutions of unequal duration.

5. In the latter part of 1889 I took up this problem and attempted to solve the question of identity between these two remarkable bodies. I based my work on an orbit obtained by the method of the variation of geocentric distances from ten normal places between July 1889 and December 1890. The results of this investigation* differed greatly from those obtained by Chandler and left the matter in a very unsettled state. Meanwhile, Bauschinger undertook the determination of the definitive elements of the comet's orbit, and upon the publication of his results,† I began a reinvestigation of the entire subject and determined to do the work in as thorough a manner as possible. Unfortunately, however, Bauschinger found a direct solution of his normal equations impossible, the last element determined being quite uncertain. Hence the final elements as given in his paper were still subject to an uncertainty, very slight indeed, but enough to affect to some extent the character of the appulse with Jupiter. In order to take account of this uncertainty and to show our actual knowledge of the movements of this interesting body, I solved his equations anew and expressed the elements in terms of an indeterminate quantity, and this indeterminate quantity, ν, I carried through my entire work. The results of this investigation, published in 1893,‡ left the question of identity still unsettled, although the results pointed very strongly to the non-identity of the two bodies.

In the hope that the first few observations of the second appearance of the body in 1896 would completely settle the question, I carried the elements forward, and found an ephemeris for the time of its return.§ The comet was rediscovered by Javelle at Nice on June 20, 1896, very close to the predicted place, and from the observations a close approximation to the value of the indeterminate, ν, was made.¶ With this a better determination of

* *Astro. Jour.* No. 244.

† "Untersuchungen über den periodischen Kometen 1889 V (Brooks)," 1 Theil.

‡ "Researches upon Comet 1889 V," *Astr. Jour.* Nos. 302, 303.

§ "Preliminary Note on the Reappearance of Comet 1889 V," *Astr. Jour.*, No. 320, p. 63.

¶ "Note on the Periodic Comet of Brooks and Javelle," *Astr. Jour.* No. 380, p. 175.

the character of the appulse to Jupiter in 1886 was made, and the result seemed to conclusively prove the non-identity of the two bodies.

6. Bauschinger carried on his investigations and determined in a most painstaking and satisfactory manner the elements which best represent the observations of the comet during the two appearances of 1889-90 and 1896-97.* The final elements obtained by him differed but slightly from those I had obtained, as above mentioned, and, therefore, the conclusions which I had reached were not altered by his later investigations. The elements which he obtained, however, did not represent the observations with the accuracy that could be desired. As pointed out by Bauschinger, the differences between the observed and computed places of the comet varied periodically. In the first appearance, 1889-90, the point of the comet which was measured, appeared a little south, and in the second appearance, 1896-97, a little north of the places computed from the mean path, and the total differences amounted to about 3″.0. Bauschinger explained these discrepancies as due to one of two causes. First, that different portions of the comet were measured during the two appearances, owing to local changes in the brightness of the object. Second, actual changes in the position of the nucleus of the comet, due to perturbations by the smaller, and in the latter appearance, invisible, companions.

The elements, as deduced by Bauschinger, were carried forward by Neugebauer, and an ephemeris computed for the third appearance in 1903. The comet was rediscovered on August 18, 1903, by Aitkin, at the Lick Observatory and was found to be very close to the predicted place; the difference between observation and theory being about 24ˢ in right ascension and 1′ 30″ in declination.

7. It seemed desirable to correct my work, heretofore mentioned, by means of the latest data, and to collect and publish in final form the results of my various investigations upon the appulse to Jupiter in 1886 and the consequent changes in the orbit of this body. In this I was greatly aided by a grant of money by the Trustees of Columbia University, which was used in employing assistant computers. The first step was the selection of the elements on which to base my investigation and here at the outset I was confronted by a difficulty. A comparison of Bauschinger's elements with the positions of the body at the

* "Untersuchungen über den periodischen Kometen 1889 V, 1896 VI (Brooks)," 2 Theil.

time of discovery in 1903 showed that these elements were not all that could be desired, and a redetermination of the elements was decided upon as a preliminary. In this redetermination all the data from the first two appearances were used and the elements deduced therefrom were checked with one or two normal places from the 1903 appearance. Thus the elements may be regarded as definitive for the appearances of 1889 and 1896, but

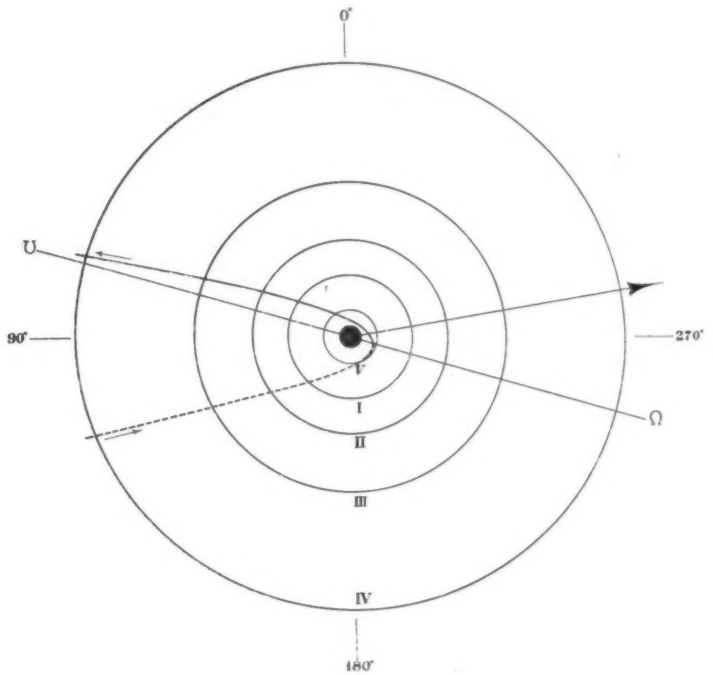


FIG. 1. Passage of Comet Brooks through Jupiter's Satellite system. The plane of the drawing passes through the center of Jupiter and is parallel to the ecliptic. The orbits of the Satellites are inclined approximately 2° to this plane: the orbit of the comet is inclined 61° to this plane and intersects the plane of reference in the line ♋♌.

not for the appearance of 1903. It was not deemed advisable nor necessary to wait until the present appearance shall be over so as to include all the observations of this appearance, as this would probably delay the work for a year or more.

The present paper, therefore, naturally divides itself into two parts:

1. The determination of the elements which best represent the motion of the comet at the time of its discovery in 1889.

2. Using the elements, thus determined, as a basis, the discussion of the action of Jupiter upon the comet in 1886, and a determination of the most probable orbit previous to that date. In this part is included the discussion of the possibility of the identity of this comet with that of Lexell.

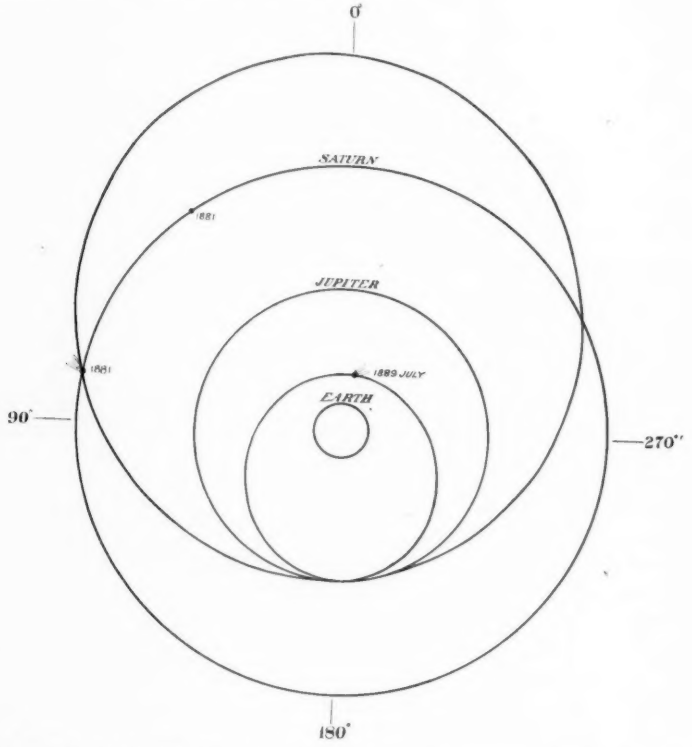


FIG. 2. New and Old Orbits of Comet Brooks. The present orbit of the comet is the small ellipse on which the position of the comet is shown at the time of its discovery in 1889. The old orbit of the comet is the large ellipse on which the position of the comet in 1881 is shown. The appulse to Jupiter occurred in 1886 in longitude 188°, near the point of tangency of the two ellipses.

CONCLUSIONS.

(*a*) The results of this investigation go very far towards proving the non-identity of Comets Brooks and Lexell, although

they are not conclusive and admit the possibility of such an identity.

(*b*) The computations upon which Chandler based his conclusion of identity of these two bodies are shown to be insufficient on account of the omission of certain important perturbations.

(*c*) Any conclusions as to the path of the comet previous to 1886 must depend to a large extent upon the perturbations suffered by the comet while in the immediate vicinity of Jupiter and due to the elliptical figure of that planet. In any further discussion of the path of this comet these figure perturbations must be most carefully investigated.

USE OF GRAPHS IN TEACHING ASTRONOMY.

SARAH F. WHITING.

FOR POPULAR ASTRONOMY.

The Whitin Observatory of Wellesley College is primarily a student's astronomical laboratory. Some experiments have been there made as to the kind of individual work by the student which would serve to train the reasoning powers, to enforce facts, and the methods by which they have been obtained, and yet which are practicable for the large number who elect a general course in astronomy, chiefly for the purpose of culture.

Besides the evening observing work for which there is a regular program, but which must as to times and seasons wait on the stars and the weather, the Observatory is open four half days in a week, with a demonstrator present, for various exercises with ephemeris, globes, charts, photographs and minor instruments. It is possible that the very simplicity of some of the exercises which have evidently been delightful and profitable to students may be suggestive to others. This article will consider some uses of the ephemeris and plotting paper.

We suspect that that mine of astronomical riches, the *American Ephemeris* is too seldom familiarly used by teachers and students of Elementary Astronomy. It not only furnishes every detail of information in reference to the heavenly bodies at first hand, but the data by which the student may himself derive many further facts which will come to him with that freshness and emphasis which always accompanies what one has one's-self made out.

Plotting paper* serves very well to represent, on the Mercator

* Metric plotting paper in convenient sized sheets and of good color for the eyes can be obtained of F. T. Tilton & Co. 898 Broadway, N. Y., and doubtless elsewhere.

projection, the belt of the zodiac, so that on such paper the path of Sun, Moon and planets can be conveniently traced from coordinates taken from the *Ephemeris*, and their relations studied. We see these paths often published in POPULAR ASTRONOMY, for example, in the January number, and what follows is only to show that such plots made on a large scale, and by the student himself, have special value. Directions for the exercises to which we refer, as they have been given to the students this academic year here follow, since in no other way can the method and results more easily be made clear. It is possible that not only students, but amateurs who are interested in astronomical study and who enjoy drawing to scale, may find this kind of work of interest.

STUDIES OF THE MOTIONS OF MEMBERS OF THE SOLAR SYSTEM AS SEEN FROM THE EARTH BY MEANS OF GRAPHS.

Material, the *American Ephemeris** and loci paper ruled in millimeters; also knitting needles,† sharp pencil, colored inks.

JUPITER PLOT.

1. Study the ephemeris of Jupiter for the year. Note that the right ascension of the planet increases, that is the planet moves with direct motion, eastward, for some months, and then that the right ascension decreases, that is the planet moves westward or retrogrades for some months, when it again resumes eastward motion. Mark the dates of the beginning and end of the retrogradation period.

2. Head a page of the notebook, "Coördinates of Jupiter," and in three columns record the date, the right ascension and the declination, for such a time as will place the westward path of Jupiter near the middle of the sheet. Two dates a month are enough except near the turning points.

3. Use a sheet of plotting paper lengthwise. Let four centimeters represent twenty minutes of right ascension and five degrees of declination. Since for the present Jupiter's declination is north, let the bottom line of the paper be the equator and graduate from the left hand corner both in right ascension and declination.

* The *American Ephemeris* can be obtained three years in advance by addressing the Superintendent of the *Nautical Almanac*, Naval Department, Washington, D. C., price $1.00. The *Ephemeris* should always be in hand a year in advance.

† Since it is important that photographs, globes, charts used by many students should not be unnecessarily handled or marked by pencils, it is convenient to have plenty of knitting needles on the tables to be used as pointers.

4. With a knitting needle in the left hand, and a sharp pencil in the right, plot in the points and make through them a smooth, fine line with ink. Put, in small printing, beside the points the dates at the beginning of each month.

5. From the star chart find the most conspicuous stars near the planet, obtain their coördinates from the *Ephemeris* and put them on the plot.

6. Take out from the *Ephemeris* the proper coördinates for the apparent path of the Sun (the ecliptic), and put it on the plot.

Saturn and Mars Plots.

The same directions serve for making the plots of the paths of Saturn and Mars. In practice it is found most convenient for the instructor to take out the coördinates required, and have several copies on the table, the student taking out only those of one planet for herself. In this way fewer copies of the *Ephemeris* suffice.

Venus Plot.

1. Put together three sheets of plotting paper the long way. (Practically it is better to have this done beforehand as clerical work, and the sheets ready for the class.)

2. Inspecting the coördinates in the *Ephemeris* it is noted that Venus' retrogradation loop does not occur until April-May 1905. Therefore take out and record coördinates of Venus beginning June 1904 for the 1st and 15th of each month. On another sheet take out the coördinates of the Sun for the corresponding dates.

3. Let each millimeter be one degree of declination or four minutes of right ascension. Place the equator in the middle of the paper and graduate the hours on it, and the declination north and south.

4. Plot in the Sun's position, locating each point by a black dot with the date beside it in fine lettering. Connect these positions by a smooth curve in black ink. Similarly plot the path of Venus, marking its positions with red ink dots and tracing its path by a fine red ink line.

5. From your star chart and the *Ephemeris* put in any 1st and 2nd magnitude stars which will come upon the plot.

Moon Plot.

Take out from the *Ephemeris* the coördinates of the Moon at noon each day for the lunation beginning Dec. 5, 1904. Also the coördinates of the Sun on the dates of new and full Moon.

2. Put in with sharp pencil on the Venus-Sun plot the points

which mark the Moon's position, marking each point by a minute crescent turned convex towards the Sun. Trace the path with green ink.

After these plots have all been made, the following questions are given to the students to be answered in the notebook, also a little strip of checked paper to be used as a measuring scale.

QUESTIONS FOR THE STUDY OF GRAPHS.

Jupiter. 1. Is the path of Jupiter now north or south of the ecliptic?

2. Is its latitude increasing or decreasing? What is its latitude by measurement at the point where it is greatest? (Measure in some place where Jupiter is advancing.)

3. How many days did Jupiter retrograde? Find its right ascension at the middle day, and compare with the right ascension of the Sun on that day and draw conclusions.

4. What reference stars have been most convenient for observing Jupiter's movements?

5. In what constellation will Jupiter be found next year?

Answer the same questions in reference to Mars and Saturn.

QUESTIONS ON THE VENUS PLOT.

1. Where the plot begins was Venus east or west of the Sun, morning or evening star?

2. Where did Venus pass to the other side of the Sun?

3. Measure and record in tabular form the elongation of Venus from the Sun at the beginning of each month. Inspect this table and state the dates when Venus became evening star and morning star again, and when its elongation was greatest.

4. Find from the plot the dates of nodes.

5. Measure between two nodes the inclination of Venus' path to the ecliptic.

6. Find the interval between the two passages of the ascending node, and state the periodic time of Venus.

7. Take from the *Ephemeris* the "configurations" of Venus, compare with your deductions from the plot. Explain by use of a drawing which neglects the Earth's motion where Venus has been moving in its orbit.

QUESTIONS ON THE MOON'S MOTIONS.

1. At new Moon Dec. 6, was the Moon north or south of the ecliptic?

2. Give the date of each node and state whether ascending or descending.

3. Measure the latitude of the Moon at a point intermediate between two nodes, i. e. the inclination of its orbit to the ecliptic.

4. Measure in degrees the distances moved by the Moon each day and record in tabular form with dates. Inspect the table and state about what dates the Moon's daily motion was greatest and least. Account for this difference in daily motion.

5. At what date did the Moon complete a sidereal month, at what date the synodic? How many days in each?

6. Measure the number of degrees of the Sun's apparent motion between the two new Moons, i. e. its motion during the synodic month. How does this measured distance of motion in December-January compare with its mean motion for a month. Account for this more rapid motion at this time.

It will be seen that in answering these questions from inspection of the plots, the student has made out the fact of the inclination of the orbits of the planets and Moon to the ecliptic, with its approximate amount, the fact that retrogradation occurs at opposition, the relative apparent motions of Venus and the Sun causing the phenomena of morning and evening star, the approximate periodic time of Venus, the difference between the sidereal and synodic month, even the place of perigee and apogee in the Moon's motion and of perihelion in the Sun's.

It is well to require a comparative table to be finally made of the rough measurements from the plots and the accurate elements of the planets from the books.

A further valuable use of the graph permits the student to find out the fact of the sun-spot period with its peculiarities.

Wolf's numbers* with the explanation of their meaning are given to the students upon a card. A page of loci paper is graduated lengthwise from its left hand lower corner so that one centimeter horizontally represents two years, and one centimeter vertically twenty of Wolf's units.

After the curve is formed the dates of maxima are taken from it, and tabulated in the notebook, also the dates of minima. The mean interval between maxima and between minima can thus be found, and the average of the two gives the sun-spot period to the first place of decimals.

Further inspection of the curve, in answer to questions, brings out several relations, as the steepness of the curve from minima to maxima, the fact that the minima and maxima differ, that there are irregularities in the increase and decrease of spots.

The behavior of all "New Stars" is clearer from a careful study

* Wolf's numbers can be found in *Monthly Weather Review* for Nov. 1901. Discussion of these numbers is found in POPULAR ASTRONOMY for Nov., 1902.

of a typical nova,—Nova Persei 1901. Coördinates for its light curve taken from Professor Wilson's list* are given students on a card. Beginning with Feb. 20, and ending Apr. 21, let each centimeter of abscissae represent two days, and of ordinates two magnitudes, beginning with the 11th in the lower left-hand corner and graduating upward with diminishing values. (The curve can be continued on the upper half of the paper.)

When the curve is plotted, the student is asked to inspect it and answer several questions in reference to the fluctuations of the light of the Nova. Opposite the proper places on the curve the color of the star and the description of its spectrum is written. The student can then see the relation between light, color, spectrum, etc.

Other relations can be studied by this method as occasion suggests, as the relation of the Sun, Moon and node in eclipses, the occultation of bright stars, etc. The student gains more by plotting a curve himself than by much looking at the same in astronomical publications.

WHITIN OBSERVATORY,
WELLESLEY COLLEGE, WELLESLEY, Mass.

THE ORBIT OF β 395 = CETI 82.

R. G. AITKEN.

The star Ceti 82 was found to be a close double by Burnham in 1875. From the large proper motion common to the two components (about 1″.4 in 90°) it was at once evident that it would prove to be an interesting physical system; but because of its southern declination and the small apparent separation of its components no observations were secured until 1886. The measures of the next five years showed so little change that in 1891 Burnham's note on the pair was, "certainly a binary, but the motion is slow."

From 1891 to 1897 no observations were made, but in the latter year See measured it and found a remarkable change. The angle had increased about 160° and the distance had decreased to less than half its value in 1891.

The observational data at that time were not sufficient for a reliable orbit, and later observations, mainly at the Lick Observatory, while confirming the rapid orbital motion, have indicated a very different orbit from the one computed by See in

* See POPULAR ASTRONOMY November, 1901.

1897 (*A. N.* 144: 359, 1897). For several years after 1897 the apparent distance increased, reaching a maximum value of nearly 0.″6 in 1900, and then again diminished. Measures on two good nights in December 1904 gave the following position:

1904.96 332°.8 0″.20

From the data now available I have computed the orbit that follows. Though the eccentricity is smaller than is usual in double star orbits, the elements represent satisfactorily the observations so far obtained.

ELEMENTS.

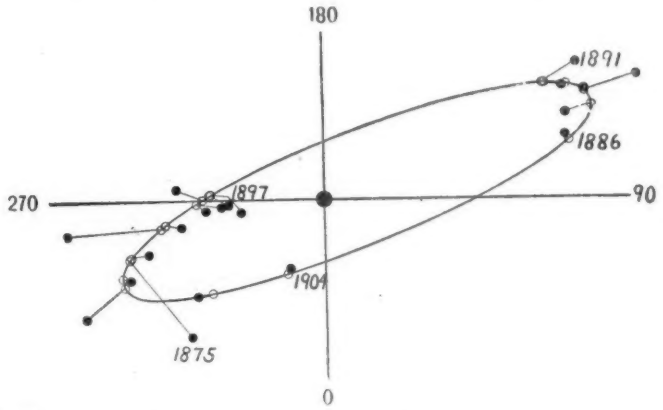
$P =$	24.0 years	$\Omega =$	110°.8
$T =$	1899.7	$\omega =$	159 .4
$e =$	0.15	$i = \pm$	76 .65
$a =$	0″.66	$\mu =$	15.00

Apparent motion direct.

EPHEMERIS.

Date.	θ_c	ρ_c
1905.7	5°.3	0″.16
6.7	58 .3	0 .20
7.7	82 .1	0 .32
8.7	92 .6	0 .44
9.7	98 .6	0 .56
1910.7	102 .6	0 .65

The following table gives a list of all the observations known to me, with the computed positions and the residuals. It will be seen that I have reversed the quadrant in several cases; but the two components are so nearly equal in magnitude that, as Burnham has said,* "a correction of 180° may be considered as allowable in any of the measures." It may also be noted that the position given by Burnham at the time of discovery is the result



* *Publications Yerkes Observatory*, I, 9, 1900.

of an *estimate* with a 6-inch telescope, and that the accurate representation of my last observation is purely accidental.

The diagram shows the apparent ellipse derived from the elements, and the straight lines connect the corresponding computed and observed positions.

Date.	θ_o	ρ_o	θ_c	ρ_c	O − C $\Delta\theta$	O − C $\Delta\rho$	Obs.
	°	″	°	″	°	″	
1875.84	135.±	0.5±	286.6	0.54	+28.±	+0.26	−0.0±	β
86.85	104.7	0.65	103.2	0.66	+ 1.5	+0.02	−0.01	LM
88.01	109.4	——	106.7	0.73	+ 2.7	+0.03	—	Pol
88.89	109.6	0.67	109.1	0.75	+ 0.5	+0.01	−0.08	Lv
89.99	111.4	0.88	112.1	0.74	− 0.7	−0.01	+0.14	Hl
90.82	112.6	0.74	115.0	0.70	− 2.4	−0.03	−0.04	β
91.83	115.2	0.69	117.6	0.64	− 2.4	−0.03	−0.05	Lv
91.85	118.2	0.75	117.7	0.64	+ 0.5	+0.01	+0.11	β
97.65	278.2	0.22	267.6	0.30	+10.6	+0.06	−0.08	See
97.67	272.8	0.25	267.9	0.30	+ 4.9	+0.03	−0 05	Cog
97.82	85.9	0.39	270.0	0.32	− 4.1	−0.03	+0.07	β
97.92	273.7	0.27	271.5	0.34	+ 2.2	+0.01	−0.07	A
97.92	275.1	0.31	271.5	9.34	+ 3.6	+0.02	−0.03	Hu
98.59	280.4	0.38	278.6	0.42	+ 1.8	+0.01	−0.04	A
98.69	97.5	0.68	279.5	0.43	− 2.0	−0.01	+0.25	β
99.72	286.7	0.48	286.2	0.53	+ 0.5	+0 00	−0.05	A
99.92	108.1	0.72	287.0	0.53	+ 1.1	+0.01	+0.19	See*
1899.92	105.8	0.66	287.0	0.53	− 1.2	−0.01	+0.13	Brown *
1900.69	292.2	0.55	290.7	0.57	+ 1.5	+0.01	−0.02	A
00.80	116.0	0.70	293.2	0.57	+ 2.8	+0.03	+0.13	Dool
03.67	306.7	0.42	309.1	0.38	− 2.4	−0.02	+0.04	A
1904.96	332.8	0.20	332.8	0.22	± 0.0	±0.00	−0.02	A

It will be noticed that the double sign (±) is prefixed to the i in the elements printed above. In stating my reasons for this, I wish to call attention to the matter of the notation employed by computers of double-star orbits. It is obviously desirable that only one set of symbols be used to indicate the elements of an orbit, and that each symbol have a definite significance. Computers are practically agreed as to the notation and definition of all the elements except three, the node, the angle between node and periastron, and the inclination. But in the notation and definition of these three elements great confusion exists, and it is generally impossible to derive apparent places from the elements without plotting the orbit, or having recourse to the ephemeris given by the computer. The orbit of Sirius may be cited as a good illustration. In three different orbits we find:

Burnham†		Zwiers‡		Doberck§	
Ω	40°.3	Ω	44° 30′.2	Ω	225° 49′
λ	135 .4	π−Ω	212 6 .4	λ	29 54
i	50 .8	i	46 1 .9	γ	43 20

* These observations were overlooked at first and hence are not represented in the diagram.

† *Publications Lick Observatory* 2: 239, 1894.

‡ Koninklije Akademie van Wetenschappen Te Amsterdam, Proc. Sect. of Sciences, 2, 17, 1899.

§ *A. N.*, 166: 321, 1904.

Two other computers (Howard, *A. J.*, 10: 235, 1891, and Mann, *Pop. Astron.*, 4: 488, 1897,) write "position of periastron" instead of ($\pi - \Omega$) and assign the values 48° 35′ and 221.°0, respectively.*

As micrometer measures alone do not afford the data necessary to discriminate between ascending and descending node, it is a matter of indifference which point is distinguished by the sign ☊. See and Burnham have therefore adopted the practice of taking ☊ always between 0° and 180°, and of measuring the angle from node to periastron from ☊ in *the direction of motion*, from 0° to 360°. Their example should be followed by all double star computers, for thus the present confusion will be largely done away with. But there is another point to be considered. Spectrographic methods have now attained a degree of precision sufficient to enable the observer to measure the variable velocities in the line of sight of the components of some of the visual binaries.† By combining spectrographic measures with those made with the micrometer, the orbit is completely defined. It is therefore very desirable to assign such definitions to Ω, ($\pi - \Omega$) and i in the orbits derived from micrometer measures alone, that no changes in their *numerical* values may be necessary when spectrographic observations have removed the ambiguity in the inclination.

This matter has been carefully considered by the writer in discussion with Dr. Campbell, and the following system, suggested by the latter, is offered as meeting all the requirements:

1. T, P, e, and a to have the usual definitions.
2. Ω to be taken between 0° and 180° in all cases, and to be considered merely as "nodal point," the distinction between ascending and descending node being entirely disregarded.
3. ω, ‡ the angle between Ω and T, to be measured from Ω in the plane of the true orbit and *in the direction of motion.* It may have any value between 0° and 360°.
4. i, the inclination, to be defined as the angle between the plane of the true orbit and the plane perpendicular to the line of sight opening at Ω in the direction of motion. It is always to

* In Rambants article "On the Parallax of Double Stars" (*Mon. Not.* R. A. S., 4: 307, 1890) the negative sign is prefixed to the revolution periods of double stars whose position angles decrease with the time. Thus the period of the companion to Sirius is written—44 years. This notation is also used by Biesbroeck (*A.N.*, 167: 75, 1905).

† See Dr. Campbell's paper on "The Variable Radial Velocity of Sirius," in *Bulletin* Number 70.

‡ The symbols ω, i and n are preferred to λ, γ and μ because they are in general use to denote the corresponding elements of comets and planets.

be taken between 0° and ± 90° and is to have the double sign (±) until measures of radial velocities have removed the ambiguity. Later, the sign (+) will indicate that the companion in passing through ☊ is relatively receding from us, the sign (—) that it is relatively approaching us.

5. μ, the mean annual motion, always to be counted positive, no matter whether the position angles in the apparent orbit increase or decrease with increasing times.

6. The direction of apparent motion, direct or retrograde, to be stated.

The only change in the elements of a visual binary defined on this system that will be needed when spectrographic measures have defined the inclination uniquely is that a definite sign will be substituted for the double sign of the i. On any other system ☊ and ω are liable to be changed by 180° and i to $180° - i$.

In computing the positions in the apparent orbit the ordinary formulæ for elliptic motion will be used to obtain the r's and v's, the true anomalies to be considered in all cases as increasing positively with the time. Then θ and ρ follow from the equations

$$\tan(\theta - ☊) = \pm \tan(v + \omega) \cos i. \qquad (1)$$

$$\rho = r \frac{\cos v + \omega)}{\cos(\theta - ☊)} \qquad (2)$$

The upper sign in equation (1) is to be used when the position angles increase with the time; and in this case $(\theta - ☊)$ and $(v + \omega)$ are in the same quadrant. The lower sign is to be taken when the position angles decrease with the time. In this case $(\theta - ☊)$ and $360° - (v + \omega)$ are in the same quadrant.

Lick Observatory Bulletin, No. 71.

THE GREAT SUN-SPOT OF FEBRUARY 1905.*

TH. MOREUX.

FOR POPULAR ASTRONOMY.

Two spots on the Sun have been visible to the naked eye, but one of them has been so interesting on account of its size that I think it worth while to describe it particularly. It presented the largest spotted surface on the Sun that astronomers have ever observed by the aid of the telescope.

Many astronomers including Herschel have recorded observations of sun-spots that were made by the naked eye. For many

* See frontispiece for fine drawing of the great sun-spot of February 1905. [EDS.]

years I have made a study of the Sun and I have made a record of a great number of them.

When a spot is 50″ in diameter it becomes visible to the naked eye. It will then measure on the Sun 36,000 kilometers. On February 2, 1905 the sun-spot measured 180,200 kilometers in length.

Assuming the Sun's diameter on that date to be 32′ 31″.46, the angular size of the spot was 252″ or 4′ 12″.

In 1898 I observed and drew a group of spots having a diameter of 160,000 kilometers; but that group was of little importance compared with the great spot of February last. On account of the great breadth of the latter, 102,000 kilometers, the spotted surface on February 2, reached the figure of 13 milliards of square kilometers. The spot in length was one-eighth of the solar diameter.

The greatest spot that astronomers have observed and measured appeared in 1858. Its greatest length was 230,000 kilometers, but the surface covered on the Sun was only one-thirty-sixth of the solar disk, while the February spot covered about one one-twenty-ninth of it.

The following table gives the approximate positions of the group on the dates mentioned from measures taken at the Bourges Observatory.

The coördinates are measured from the center of the principal nucleus; λ being the heliocentric latitude, and L the longitude from the central meridian:

Date.		λ	L		Dist. in Long.
Jan. 31	8ʰ	— 14°	49°	E.	220″
Feb. 1	8	— 14	36	"	—
" 2	14	— 13	20	"	252
" 3	8	— 14	10	"	243
" 4	9:30	— 15	5	W.	—
" 5	9:30	— 14.5	18	"	—
" 6	9:15	— 15.5	31:35	"	—
" 8	15	— 17.5	48	"	—

The passage over the central meridian must have taken place on February 4 at two o'clock in the morning Paris M. T.

The extent of the spot in latitude was as follows:—

Feb. 2	From	— 19°	to	— 10°
" 3	"	— 18	"	— 11
" 4	"	— 20	"	— 10
" 5	"	— 18	"	— 8.5
" 6	"	— 19	"	— 11
" 8	"	— 21	"	— 11

The spotted surface being considerable, the two nuclei have made great changes in latitude, and the extent of the penumbral region has been more or less dissipated in the meantime.

Bourges Observatory, France. February 1904.

THE MARTIAN SNOWS.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

It may interest observers to know that ice will probably begin to form at *both* poles of Mars during the month of April. The north pole will be turned toward the Earth at an angle of from 10° to 13° during the month, and the meteorological changes that we may expect to see when the ice appears should be quite conspicuous, the northern ice melting rapidly in the continuous sunshine. The poles may appear either a pure white, a light yellow, or a bright but vivid green. The first indicates hoar frost or snow, the second clouds, and the third, at least in part, vegetation. The greens over a considerable portion of the planet will be particularly vivid during the present opposition, and should be visible even in small telescopes. A paper on Martian Meteorology is now in preparation for the *Harvard Annals* treating this subject in more detail, but it probably will not be ready for distribution before summer.

The planet will be from 13″ to 17″ in diameter, coming to opposition early in May, so that the disk will be large enough to be well seen. Indeed, this opposition will be particularly favorable to these observations, the planet being nearer us and better placed during this portion of its year, than during either the preceding or following oppositions. It is unfortunately rather far to the south, declination — 18°, and observations at the beginning of the month cannot be made much before midnight,—meridian passage $14^h\ 53^m$. By the end of the month observations may begin shortly before ten o'clock,—meridian passage $12^h\ 39^m$.

HARVARD COLLEGE OBSERVATORY.
March 6, 1905.

REVIEW OF SOLAR OBSERVATIONS FOR THE YEAR 1903, AT ALTA, IOWA.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

The following results of solar observations for the year 1903 are in continuation of those published in POPULAR ASTRONOMY, November 1903. The instruments used were a 4-inch refractor and 8½-inch reflector, both by Brashear, with 3 prism polarizing eye-piece.

The principal characteristics of the record for 1903, are:

1. The decided increase in the number of groups, spots, and faculae.
2. The marked decrease in the total number of spotless days.
3. The frequency of spots in the southern hemisphere, and
4. The remarkable outburst of a spot group of the first magnitude in October, which was followed by greater solar activity until the close of the year.

January. Sun-spots were few and sporadic during this month. Only a small cluster of dots made the transit of the disc, which it completed in the early days of February. The disc was free from spots on five out of the twelve days on which observations were secured.

February. Sun-spots were all small and uninteresting, but one small group made the full transit of the disc. A couple of small groups appeared during the closing days of the month and disappeared near the western limb early in March.

March. The Sun was observed on fifteen days and five of these were spotless. During the last week of the month, three interesting groups were observed, one of which was a fair-sized normal spot in the northern hemisphere.

April. More activity was evident this month than for nearly a year, or since May 1902. A fairly large spot during the first half of the month proved to be quite interesting, its large umbra dividing and coalescing again before disappearance. A few spotless days about the middle of the month were followed by several groups of small and one large group of spots, during the balance of the month.

May. Spots were all very small and transitory this month; four spotless days were recorded.

June. Only dots were visible during the first two decades of the month. A train of small spots made the transit from the 19th to the close of the month.

July. The Sun's surface was quite well dotted all this month. A large spot which entered the disc on June 30th in south latitude was spectroscopically active during many days of its transit, on the 4th and 9th the region just preceding the spot was very much disturbed, the $H\alpha$ line being reversed and distorted.

August. Principally clusters of dots and small spots were present on the disc all of this month.

September. The disc was comparatively free from spots this month, there being 11 spotless days out of the 21 on which the

Sun was observed. During the closing days, a small group increased rapidly before it disappeared at the west edge.

October. The comparative quiescence of the preceding months was followed this month by some groups of the very first magnitude. The great group of 4-17th, has already been described, [see POPULAR ASTRONOMY, No. 110, December, 1903.] Another large spot in north latitude made the transit during the same interval; this was succeeded during the middle of the month by other large spots, notably one during the closing days of the month in south latitude.

November. The month opened with two large groups present, and the region of the great October group returning to view again, this group had diminished in extent somewhat, but was still interesting and full of small nuclei during its visibility. During the latter half of the month only one or two small spots were present.

December. During the first decade of this month the third return of the October groups were on the disc, but much reduced in extent and fast diminishing in size. At the close of the year three groups still occupied this large disturbed area of the southern hemisphere.

The following table exhibits the numerical results of the observations for the year.

Months 1903	No. of Observing Days.	Average No. of Groups.	Average No. of Spots.	Average No. of Groups. Faculæ.	Average No. of Groups. N. Lat.	Average No. of Groups. S. Lat.	No. of Spotless Days.
January	12	0.60	3.60	0.60	0.25	0.33	5
February	16	1.30	3.50	1.30	0.50	0.80	1
March	15	1.47	7.01	1.30	1.20	0 27	5
April	18	2.06	7.40	1.90	1.10	0.96	2
May	18	1.30	5.80	2.00	0.67	0.62	4
June	23	1.43	7.30	2.00	0.56	0.87	2
July	26	2.15	12.60	2.15	0.85	1.30	1
August	21	1.48	8.10	2.40	0.43	1.04	0
September	21	0.67	2.43	1.90	0.43	0.24	11
October	26	1.96	10.54	1.65	0.96	1.00	0
November	19	2.47	15.00	2.16	0.63	1.84	0
December	15	2.93	11.07	3.20	1.20	1.73	1

Compared with the preceding year, there has been a decided increase in the average number of groups, spots and faculae in 1903.

The number of spotless days has decreased from 163 in 1902 to 32 in 1903.

In the subjoined table is given the annual average results for the years 1891 to 1903 for comparison:

Years.	No. of Days of Observations.	Average Annual Number of Groups.	Spots.	Faculæ.	Total No. of Spotless Days.
1891	257	2.9	14.9	3.6	24
1892	205	5.6	34.0	4.1	0
1893	177	6.6	36.6	4.1	0
1894	139	5.6	30.0	3.4	0
1895	149	5.2	30.5	3.5	0
1896	197	3.2	17.8	2.9	5
1897	198	2.2	11.0	2.3	29
1898	234	2.1	11.0	2.4	30
1899	259	1.1	4.8	1.5	108
1900	255	0.7	3.4	1.0	134
1901	269	0.25	0.9	0.3	212
1902	230	0.37	2.0	0.5	163
1903	230	1.65	7.8	1.9	32

ALTA, Iowa., February 23, 1905.

ON THE ECLIPSE OF AGATHOCLES.*

SIMON NEWCOMB.

In my "Researches on the Motion of the Moon," which appeared in 1878, I made a careful study of the accounts of supposed total eclipses of the Sun by ancient authors, with a view of determining whether any of them could be used either as tests of the lunar tables, or as auxiliaries in the determination of the slow changes in the lunar elements. The conditions required for this use were that some determinable eclipse should have been total at a known place. The conclusion which I reached was strongly in the negative. Not only did there appear to be no ancient eclipse which we could conclude was really total at a given place; but the accounts were generally so vague that no interest seemed to attach even to a comparison with the lunar tables, except for chronological or historical purposes.

I may add, in all frankness, that these adverse views have not been shared by those astronomers who, in the meantime, have made researches on the subject. Oppolzer and, after him, Ginzel had such confidence in the reality of these eclipses as to use them as the basis of corrections to the elements of the Moon's motion which are incompatible with gravitational theory. I have no intention to argue my view at present further than to say that I am not at all convinced it was in any point ill founded, so far as related to data available at the time. But since my paper was published a very important point has been brought to light showing an exception to the conclusions there reached. This arises in connection with the eclipse of Agathocles —309 August 14.

* *Monthly Notices*, December 1904.

This eclipse has been so fully discussed by Airy and others that only a very brief statement of the circumstances connected with it is necessary. The eclipse was observed from the fleet of Agathocles about 10 o'clock A. M. of the day after it put to sea from Syracuse. There is no doubt about the fleet having been well within the line of totality. Unfortunately it is uncertain, from historical evidence, whether Agathocles sailed to the north or to the south of Sicily. Consequently there are two possible positions of his fleet, one to the south of the island, the other near its north-east point. Moreover, the path of totality was quite broad, the radius being about 50′, thus much widening the range of uncertainty.

What gives real importance to this eclipse is its identification by Celoria with one referred to by Cleomedes, during which the Sun was said to have been entirely eclipsed in the Hellespont, while one-fifth of its diameter was still visible at Alexandria. This affords a very strong presumption that the path of totality passed over the Hellespont. Yet the path does not reach the Hellespont by the tables either of Oppolzer or Ginzel, the central line being a hundred miles or more to the south. What I have now done is to make a computation of the path of totality from the tables based on the corrected theory found in the researches already alluded to, using the tables in the astronomical papers of the *American Ephemeris*, vol. i, as well as testing the result by a differential reduction of Hansen's results given in his "Darlegung." The result is that, according to my tables, the path of totality passed the following points, the one near Sicily, the other south of the Hellespont:

	Central Line.				Northern Limit.			
	°	′	°	′	°	′	°	′
Longitude	15	35	23	39	15	35	23	39
Latitude	37	7	38	1	38	4	38	58

The extreme south-west end of the Hellespont is in latitude 40°, longitude 24°. According to my corrected theory, the northern limit of the path passed some miles south of this point, and, of course, yet farther south of other regions of the Hellespont. In order to bring the northern limit well into the Hellespont it would be necessary to make a yet farther diminution of the secular acceleration by about 1″.5.

Both positions of Agathocles, as estimated by Airy, fall within the computed belt of totality, so that we cannot base any conclusion on the account of that navigator.

Very interesting in this connection is the conclusion reached by Mr. Nevill in his paper in the *Monthly Notices*, vol. xxxix. p. 72.

Here the author argues vigorously against my introduction of a rather indefinitely described eclipse of the Moon used by Ptolemy; and, indeed, of the series of Babylonian eclipses of the Moon which I used in my determination of the secular acceleration. My reply to this view would only have been that I fixed the weight to be assigned to these eclipses solely upon the expressions used by Ptolemy, and did not think it expedient to make any change on account of the observed discordance. Possibly this was not the best course in a case where so much suspicion may attach to a record. Mr. Nevill's conclusion was that my result should have been still further diminished by at least 1″, and perhaps 1″.5. This view is now strengthened by the eclipse of Agathocles.

The important point is that this reduction will carry the observed acceleration down almost to the theoretical value, in which no allowance is made for tidal retardation. In other words, the conclusion to which the new evidence points is that the actual retardation of the Earth's rotation is almost evanescent. Although no numerical determination of the probable amount of retardation, as given by theory, has, so far as I know, ever been made, I think any estimate must make probable a value larger even than that corresponding to my former result. It therefore seems likely that a neutralization of tidal friction is produced by some cause not yet fully investigated.

THE ECLIPSE OF AGATHOCLES.*

W. T. LYNN, B. A., F. R. A. S.

At the last meeting of the Royal Astronomical Society a paper was read from Professor Newcomb with reference to the above eclipse, respecting which it seems to me that a few remarks may be of interest to our Association. The eclipse is one of those in which calculation has enabled us to fix with accuracy the date of an event in ancient history, and that a date of no less importance than the epoch of the first invasion of any part of Africa by an European army. At the time when a Carthaginian fleet was blockading Agathocles in Syracuse he took the opportunity of their moving to capture a convoy of provision ships, to give them the slip, and sailed away from Sicily for the purpose of attacking the enemy in their own territories. He reached Africa on the sixth day, but on the first day out an eclipse of the Sun oc-

* *Journal of the British Astronomical Association*, XV, 4.

curred which from the description would appear to have been total. It has given rise to some controversy as to the exact part of the sea where Agathocles was at the time. Of course, the nearest way to Africa was nearly south until rounding Pachynus, but Airy (see his paper in the "Philosophical Transactions" for 1853) accepted a suggestion made to him by Bosanquet that Agathocles sailed northwards to avoid the Carthaginian fleet, went through the Straits of Messina, and passed along the northern coast of Sicily before proceeding to Africa. In a letter contributed to the 24th volume of the *Observatory* I ventured to suggest that there was no occasion to assume that he so greatly increased the length of his voyage as this route would imply, that it was more probable that he stood some distance out to sea and then sailed on a south-western course to Africa. However, as the eclipse took place early in the morning after he left Syracuse at night, he could not then have been far from there, so that this question is of more interest historically than astronomically. Nor does Professor Newcomb even touch upon this point, but calls attention to another with regard to the supposed subsequent track of the eclipse; and it is on this that I wish to offer a few remarks. That the eclipse was the one which occurred on the morning of the 15th of August in the year —309 (*i. e.*, B.C. 310) there can scarcely be any doubt.

Professor Newcomb states that Professor Celoria, of Milan, has identified this eclipse with one mentioned by Cleomedes. Now, that writer speaks of an eclipse which was total over the Hellespont, but at which only about one-fifth of the Sun's disc was obscured at Alexandria. He gives absolutely no hint as to the date at which this eclipse took place, nor does he mention its having been seen in the western Mediterranean, or anywhere else. Professor Celoria's paper is in the 41st volume (p. 89) of the *Monthly Notices* of the Royal Astronomical Society. He had taken the pains to calculate the paths of all total eclipses from — 330 to — 100, that is, from B. C. 331 to B. C. 101. In all that period of more than two centuries he found none that would answer the statement of Cleomedes except the eclipse of Agathocles, hence the identification to which Professor Newcomb refers. But why did Professor Celoria stop in his calculations at B.C. 101? It seems to me that in an indefinite statement about an eclipse Cleomedes would be more likely to be referring to one in his own time than to one three centuries before it. The epoch at which he flourished is not very exactly known, but from his references (which are very frequent) to Posidonius it is evident

that his own works were composed subsequently to those of that astronomer. How much later we cannot tell, but there was an eclipse (doubtless the one mentioned by Phlegon as having been seen in Bithynia, respecting which some absurd deductions were formerly drawn but were fully refuted by Lardner) on the 24th of November A.D. 29, the zone of totality of which in all probability passed over the Hellespont. This was in the reign of Tiberius, and may have been within the life-time of Cleomedes.

There is, it seems to me, another reason why the eclipse of Agathocles cannot be accepted as identical with the one mentioned by Cleomedes. He speaks of the amount of obscuration as having been measured at Alexandria. Now, that city has certainly been *founded* before B.C. 310, but it was not under the settled government of the Lagidæ for some time afterwards. The establishment of a seat of learning there began in fact with Ptolemy Philadelphus, who became sole king in B.C. 283 on his father's death.

A THREE-INCH TELESCOPE.

WILLIAM STRONG.

FOR POPULAR ASTRONOMY.

The writer of this was highly pleased to read the articles in POPULAR ASTRONOMY for October and December last, by the editor, upon "A Three-Inch Telescope for the High School." A three-inch telescope is also a good thing for the ordinary man!

The writer of this, has, all his life of sixty-six years, lived on a farm, and his school advantages were very limited indeed—but little more than those afforded by the "deestrict skule" of the early days. Yet, like all Yankee boys, he was inclined to pry into other matters than the mechanism of the tools with which he worked on the farm. One day he got hold of an old astronomy that was owned by a more fortunate boy who had gone through college. In that old book he saw something that he did not believe to be true. This prompted him to look farther.

He next got hold of "Burritt's Atlas of the Heavens." Then in 1878, the year of its publication, he bought Newcomb's large "Popular Astronomy." This latter seemed a piece of foolish extravagance of such a nature as he had never before been guilty, yet soon after this he had captured about all of the constellations; the first, and some of the second magnitude stars; the great belt of the zodiac; all the visible planets, and the many other objects of interest visible to the naked eye. By this time he had quite a family on his hands, and a farm to manage, but

he thought all the time that he knew quite a lot of things about astronomy; hence in addition to his agricultural journals he subscribed for "The Sidereal Messenger"—took it for many years, and now has the files where he can put his hands on them at a moment's notice; and he has a pile of "Popular Astronomy" also.

Well, after he possesed that large astronomy and it told of so many things that he could not see, he became uneasy. He had occasionally seen articles by, and about Dr. Lewis Swift and his comet work, so he wrote to him at Rochester in 1879, and asked him if he would look up a good, small telescope, to cost not over one hundred dollars. He was cautioned to take all the time necessary, but to be sure and get a good one. Dr. Swift at once answered the letter, and it was so kind and encouraging that to this day it makes the writer's heart beat quicker than usual. Afterwards for years he would occasionally write and call attention to some phenomenon near at hand, to be observed with a small telescope. Late that year he found a telescope that seemed to fill the bill, bought it, and sent it on. It was made by Bardou & Son, Paris, and is almost exactly like the one figured in this journal, tripod and all. Only this one has a stem fastened to the brass tube that runs down through the head of the tripod, by which the tube can be elevated still higher if necessary, and the ratchet for adjusting the focus is at the side of the tube. Accompanying the instrument were two eye-pieces, one a terrestrial, and the other a celestial, of about 70 diameters. These were not enough, hence the owner has had two more made, one of 150 diameters, and a comet-seeker of low power and broad field. This latter adds very materially to the value of a small telescope. A sun-cap also came with the instrument.

When the telescope came, the owner thought that he had about "the whole thing." He at once unboxed it, set it up, and as Jupiter was high in the south, he at once turned it upon him. The owner knew what he ought to see, but had never seen, never having looked through such a machine. Well, when the great planet with its equatorial markings and satellites flashed upon his vision, it almost took his breath away, and no doubt he felt bigger than did Columbus when he sighted land!

That comet eye-piece was just the thing for Albireo, the glorious star clusters, and some of the irresolvable nebulæ, but the name did not fit the eye-piece unless used on comets. So he sent right away to have the "Science Observer" send its comet circulars, and they have been coming ever since. These, with the comet ephemerides in POPULAR ASTRONOMY are of so much

assistance, that a telescopic comet must be in a terribly cold place, and a great distance out in space, if the owner or his wife cannot sweep it up in short order, and then follow it night after night across the trackless, star-lit fields.

Some of the things that can be done with a small telescope have been mentioned in the articles referred to above, but there are many more, and there is no end to the joy it can bring to the individual, the family, the district school, the neighborhood, the Sunday school, the high school, the seminary, the college. During the past twenty-five years this instrument has been used many times in all of the above places, and because of the work it was seen to do, other instruments have been purchased.

But does it pay for farmers to bother with such things? Yes, yes, a hundred fold, if one gets a right view of life. In the case cited above, the farm has not been neglected, but has proved eminently successful from the stand-point of the dollar, while at the same time this astronomical part has given untold joy to hundreds, and made them more intelligent than they otherwise would be. The writings of specialists in astronomical fields can often be well understood, and thus can the reader in some measure keep up with the great advance in this science. The writings of the world's great poets are often shrouded in mystery to the man who knows nothing of astronomy. Many places in Job, Homer, Virgil, Spenser, and plenty more, even of quite modern date, are only understood by those who have the astronomical key. For instance, how can one understand what Tennyson's drift is when in his "Merlin and Vivien" he causes Merlin to say: "A single misty star, which is the second in a line of stars that seem a sword beneath a belt of three" etc.?

Because of the foregoing, and many more reasons that might be mentioned, the writer holds up both hands for the good, small, tripod-mounted telescope for high schools, and for common people, too, in their homes, and would thank you, the editors, for having called attention to the matter in this excellent journal.

KALAMAZOO, Michigan.

MOVEMENTS IN MATHEMATICAL TEACHING.*

DAVID EUGENE SMITH.†

It is now nearly a year and a half since Professor Moore gave his presidential address before the American Mathematical Society, an address provoking so much criticism that it is well to

* *School Science and Mathematics*, March, 1905.

† Teachers' College, New York City.

consider its results here in the East. It was a fact apparent to all who heard it that the address was not favorably received by many of those present. Whatever opinions may have been publicly expressed, in private there were two adverse criticisms, (1) that a man who stood among the few recognized leaders in higher mathematics in this country should lose the opportunity offered to consider the great problems of the science *per se*, and (2) that one whose field had been so peculiarly one of research should assume to enter the realm of education and to criticise existing methods.

These being the opinions of that time, it was quite apparent that the address would probably have much influence, since the ordinary paper that is pleasantly received is usually consigned to oblivion as speedily as possible. Such has proved to be the case. Either prompted or encouraged by the address, the teachers of mathematics in New England at once organized an association that has undertaken much serious and valuable work in the line of secondary education. Its members are the leaders in that section of the country, and they represent all kinds of schools, public and private, from the elementary grades through the university. Following closely upon that movement, a similar organization was formed in the Middle States and Maryland and has now been actively engaged in work for a year. Contemporary with the formation of the latter association, a conference was called at the Boston meeting of the National Educational Association, at which the question of the improvement of mathematical teaching was discussed, together with that of the organization of associations similar to those in New England and the Middle States, and steps were taken looking to such results. Meantime the Middle States movement had begun to develop into a plan for local sections similar to those of the American Mathematical Society, and already two such sections have been organized, one at New York and the other at Philadelphia.

Such are some of the results of Professor Moore's paper in the way of organizations. Of the work that will be done it is rather early to speak, but the character of the promoters is such as to assume that it will be serious and progressive. Certain it is that the results of the presidential address have been such as to abundantly justify the assertion of some of the minority of those who heard it, that it would be much more epoch-making than most of its predecessors.

It is not, however, too early to estimate the sentiment of the East as to the attitude that this section of the country will take

in relation to what has been called the Laboratory Method. Many of the leaders have discussed the question, and in no instance have I seen any desire to consider it in any manner that was not serious and dignified. There has been an earnest effort to understand it, to weigh its merits and its defects, and to adopt that which appeals to the East as usable. But after attending numerous meetings and conferences in which the matter has been carefully considered, I feel convinced that the East will encourage the Central States to continue their experimentation, but will be slow to adopt the extreme views often expressed in that part of the country. Nor is this because the East is content to stagnate and prefers to be let alone. It is true that conservatism has here its American habitat, but the attitude concerning the Laboratory Method arises neither from this feeling nor from ignorance; it comes from a knowledge of what the East demands that other sections do not, and from a conviction that it is not feasible to go to the extreme to which certain parts of the West have gone.

In general, the views of Eastern teachers of the highest rank seem to include the following details as to the question in hand:

1. Any effort to introduce physical experiments to any extent into the classes in mathematics has no support whatever, from either the teachers of mathematics or those of physics. The testimony of men of highest rank in secondary education, open-minded and practical men who have seriously tried the experiment for sufficient lengths of time, men who are working in schools where conditions were favorable, has been unanimously opposed to the plan.

2. Any effort to seek the applications of mathematics chiefly in physics, or in science generally, has not met with favor, and is not likely to find advocates. The consensus of opinion is that the number of applications of algebra to physics, for example, is exceedingly small, those to business problems being considerably larger, even though these are not numerous. A serious effort is being made in numerous instances to find every genuine application of secondary mathematics, but the feeling is generally expressed that there is as much danger of forced, uninteresting, abstract applications in certain of the physical problems proposed as in many of the inheritances against which we all protest.

3. The attempt to have algebra and geometry appear to the pupil as subjects having any considerable application to science or to business aside from a few special propositions, will not be made. To arouse an interest in these sciences, applications will

be sought in every direction and the genuine ones will be used, the game element will be made prominent, and the taste for discovery will be fostered at every step, but the East will use all this as a crutch to get the pupil to walk in the domain of pure mathematics. This is the domain that interests this section of the country, this is the work that our elaborate system of rigid entrance examination demands, and here is the field for improvement of education that strikes the Eastern leaders. How shall we bring our pupils to love mathematics for its own sake, to be discoverers themselves, to look into methods of attack, and to appreciate the elaborate interrelations of propositions, topics, subjects?—this is the great question that attracts our teachers. If some physical problem will assist, well and good, but this is a mere incident; that no equation shall be given without a genuine application, that no problem shall be assigned without physical content, that no topic shall be considered save as it bears upon life—to all this there is bound to be a negative response.

4. There is, however, one phase of laboratory work that is being seriously considered by some of our leaders, men who feel that this is the essential good of the plan and that it has been obscured by relatively unimportant details. It is that the class room shall be a workshop, not in applied but in pure mathematics. This, of course, means that we are to see how much of the spirit of a German gymnasium mathematical class can be transplanted into our schools. A workshop, with the tools of pure mathematics, with the pupils busily at work, with the teacher encouraging and directing, with part of the hour given to rapid, intensive discovery, and the rest to reports (recitations, if you please)—such a picture is in the minds of many with whom I have talked, and who have seen the German system in its own home. Whether the time will come when the recitation hour can be lengthened enough for such work, whether the school day in our cities will admit of such change as to allow most of the studying to be done in the class room, is a serious question. The trouble, from our standpoint, is that the argument for mathematics holds equally well for other subjects, and the problem thus becomes exceedingly complicated. But this phase of genuine laboratory work appeals to many teachers, and the fact that it is recognized is hopeful.

5. The fact that the college entrance examination plays a much more important part in the East than in other sections of country has led to some question as to the attitude of our schools to the movement. But this has not been considered a

serious matter. It is increasingly noticeable that the examinations demand power rather than the memorizing of facts, and hence the best system of teaching is the one that will carry the day.

In conclusion, the feeling in the East, as I interpret it after much study, is one of earnest desire to make the class in mathematics a workshop, but in the high school it must be a workshop in pure mathematics. In arithmetic, where the field of real application is very large, there is a manifest desire to banish those problems that pretend to relate to business and science, but do not do so, to substitute genuine ones in their stead, but to hold to such an amount of abstract work as to bring that mechanical efficiency that is necessary to fairly rapid and accurate computation. In algebra and geometry, where the field of real applications is very small, the chief effort will be to turn the class into a laboratory in pure mathematics, recognizing that the applied problem shall be used as one of several means for arousing interest, but that this is a mere incident.

To the Western mind this may seem a conservative position. Those of us in the East who have lived in the West long enough to acquire some of the spirit of that section appreciate this feeling. But the above statement represents not merely what is the present attitude of the East, but what is the probable future attitude of the East, but what is the probable future attitude on this matter.

In this section the attitude is felt to be the judicial one, and it is probable that in the Central States there will be found many who think that it is such. But of the good results arising from Professor Moore's paper there are few teachers of mathematics who can doubt. It set the East thinking, and while the East thinks slowly it thinks judicially, while it works conservatively it works thoroughly, while it is not given to rash experiment it is not blind to results, and while it is influenced by traditions it is ready to change when it sees other plans proved to be better than its own.

THE SEMI-DIAMETER OF THE PLANETS.

ROBERDEAU BUCHANAN.

FOR POPULAR ASTRONOMY.

Although the planets are nightly observed by hosts of astronomers all over the world it is strange that their semi-diameters have not been determined with such precision that the same

values should be generally adopted by the Nautical Almanac Office of the several nations.

The reduction of the planet's place from an observation of one limb depends upon the *Nautical Almanac* value of the "time of the semi-diameter passing the meridian." The time of a planet's occultation by the Moon depends upon the semi-diameter; and also the Lunar Distances where a planet's limb is observed, and therefore a ship's longitude at sea.

The values of the semi-diameters given in the *American Nautical Almanac* (page 586 for 1905) are the semi-diameters at the "Log Distance" which is only a roughly assumed approximation to the planet's mean distance from the Earth.

A planet's mean or average distance from the Earth is; for an inner planet, the astronomical unit, the *Earth*'s mean distance from the Sun; and for an outer planet it is the same as the *planet's* mean distance from the Sun, which in other words is the semi-major axis of its orbit.

Let s be the semi-diameter at true distance p and s_0 the mean semi-diameter given in the *Almanac* at the distance p_0 also there given, then we have

$$\frac{s}{s_0} = \frac{p_0}{p} \qquad \text{whence} \qquad s = \frac{s_0\, p_0}{p}$$

Here $s_0\, p_0$ is a constant and the two factors are not often used separately except in mathematical investigations. It is the semi-diameter as seen from the Earth at units distance, (the astronomical unit) *European Nautical Almanacs* instead of giving the value of s_0, usually give the constant $s_0\, p_0$; some almanacs give both; and moreover they do not agree in their adopted numerical values. The United States is the only work which gives the distance. A comparison of these values may be interesting to readers of POPULAR ASTRONOMY.

SEMI-DIAMETERS OF THE PLANETS.

Planet.	American Ephemeris.			British Nautical Almanac.		Connaissance de Temps.	Berliner Jahrbuch.	Almanaque Nautico.
	s_0	log p_0	$s_0\, p_0$	1907		1906	1905	1905
	"		"	"	"	"	"	"
Mercury	3.34	0.00	3.34	3.34	8.63	3.34	3.34	3.34
Venus	8.546	0.00	8.546	8.40	11.61	8.305	8.78	8.42
Mars	2.842	0.25	5.05	4.68	3.07	5.55	4.68	5.30
Jupiter Eq.	20.00	0.70	100.23	97.36	18.71	99.703	99.8	99.10
" Polar	18.78	0.70	94.12	91.10	17.51		92.6	92.86
Saturn Eq.	9.38	0.95	83.61	84.75	8.88	81.105	81.4	83.15
" Polar	8.77	0.95	78.16	76.88	8.06		73.4	76.58
Uranus	1.68	1.30	33.52	34.28	17.9	37.40	34.7	35.06
Neptune	1.28	1.48	38.21	36.56	1.22		45.	37.60

The quantity $s_0\, p_0$ of the *American Ephemeris* is not there

printed but merely given here for comparison with the other publications.

The above works,— the *American Ephemeris* of the United States, the *British Nautical Almanac* of England, the *Connaissance de Temps* of France, the *Berliner Jahrbuch* of Germany, and the *Almanaque Nautico* of Spain are the five principal astronomical and nautical ephemerides of the world; but there are others which are mere reprints of one of these.

The equatorial and polar semi-diameters of Jupiter and Saturn are generally given. The latter is generally used in the body of the almanacs, but the former is used for the time of the "semi-diameter passing the meridian."

The great discrepancy of values shown above suggests the need of a general revision and the determination of values which would be accepted by these five publications. Mars seems to be mostly in error, and the coming oppositions of 1905-7-9 should be taken advantage of.

PLANET NOTES FOR MAY, 1905.

H. C. WILSON.

Mercury will be morning star during May and will be visible toward the east, about an hour before sunrise during the latter half of the month. The planet will be at greatest elongation, west from the Sun 25° 26′, on the morning of May 21.

Venus will also be morning star during May. She was at inferior conjunction April 27 and so will be hidden by the glare of the Sun for a few days, but by May 5 or 6 she ought to be visible to the naked eye for a few minutes, if one should look at just the right time before sunrise. Toward the end of the month she will become very brilliant again, almost equalling her brightness in March.

Mars will be at opposition on May 8 and so will be in good position for observation during all the month. It will be nearest to the Earth on May 16, when its apparent diameter will be nearly 19″. Unfortunately northern observers for the planet will be too far south of the equator to expect very general good seeing. Its course during May will be retrograde in the constellation Libra. A telegram received March 9 from Mr. Percival Lowell, who has a private observatory at Flagstaff, Arizona, and has devoted his attention especially to the study of Mars, states that "functional alternation in the visibility of Thoth and Amenthes (canals) on Mars has again been observed. Both canals are double."

Jupiter will be in conjunction with the Sun May 3 and so will not be observed during this month. A telegram from Lick Observatory, Feb. 27, announces the discovery by Perrine of a seventh satellite of Jupiter, by means of the Crossley Reflector photographs. The new satellite, like the sixth is exceedingly faint and can be seen only with the aid of the great telescopes.

Saturn will be at quadrature, 90° west from the Sun, May 23 and may be observed as a morning planet in the constellation Aquarius.

Uranus is to be found, after midnight, in the constellation Sagittarius in a bright part of the Milky Way. It is not visible to the unaided eye but may easily be distinguished with a small telescope.

Neptune may be observed in the early evening in the constellation Gemini (See chart in our February number p. 96).

THE CONSTELLATIONS AT 9 P. M. MAY 1, 1905.

Occultations Visible at Washington.

Date. 1905.	Star's Name.	Magnitude.	IMMERSION. Washington M.T.		Angle f'm N pt.	EMERSION. Washington M. T.		Angle f'm N pt.	Duration.	
			h	m	°	h	m	°	h	m
May 10	B.A.C. 2888	6.3	12	05	85	12	53	301	0	48
14	η Virginis	4.0	14	10	133	15	00	265	0	50
15	4ϵ Virginis	6.1	4	56	79	5	48	328	0	52
15	48 Virginis	6.5	6	47	58	7	25	355	0	38
16	94 Virginis	6.6	9	38	61	10	22	350	0	44
16	95 Virginis	5.4	10	03	138	11	14	272	1	11
20	Lalande 33327	6.3	12	10	147	13	00	225	0	50
23	Mayer 889	5.7	11	15	129	12	01	219	0	46
24	B.A.C. 7599	6.1	12	18	25	12	57	313	0	39

COMET AND ASTEROID NOTES.

New Asteroids.—The following have been added to the list of new minor planets since our last note:

	Discovered by	at	Local Mean Time.			R. A.			Decl.			Mag.
				h	m	h	m		°	′		
1905 PW	Götz	Heidelberg	1905 Jan. 8	12	58.5	8	26.8		+17	16		12.0
PX	Wolf	"	26	10	45.6	8	41.5		+15	47		11.6
PY	Wolf	"	26	10	45.6	8	54.6		+16	09		13.3
PZ	Wolf	"	Feb. 9	8	46.9	8	44.0		+18	46		13.5
QA	Wolf	"	9	11	51.9	9	47.5		+11	19		13.5
QB	Wolf	"	9	11	51.9	9	47.9		+13	04		12.0
QC	Wolf	"	9	8	46.9	8	42.5		+16	29		13.3

1905 PW was at first supposed to be identical with (517) [1903 MH] but is now found to be new, and PX is probably identical with (517). QB is perhaps (180) Garumna and QC is probably (427).

Numbering of Recently Discovered Asteroids.—In *A. N.* 3994 and 4000 Professor J. Bauschinger, Director of the Berlin Astronomical Computing Institute assigns the following permanent numbers to asteroids which were discovered in 1904, all of these having been observed a sufficient number of times to furnish data for good approximations to their orbits.

No.	Provisional Designation.	Discoverer.	Date of Discovery.	Computer of Orbit.
522	1904 NC	Wolf	1904 Jan. 10	Lassen
523	ND	Dugan	Jan. 27	R. I.
524	NN	Wolf	Mar. 14	R. I.
525	NO	Wolf	Mar. 14	R. I.
526	NQ	Wolf	Mar. 14	R. I.
527	NR	Wolf	Mar. 20	R. I.
528	NS	Wolf	Mar. 20	R. I.
529	NT	Wolf	Mar. 20	R. I.
530	NV	Wolf	Apr. 11	R. I.
531	NW	Wolf	Apr. 12	R. I.
532	NY	Wolf	Apr. 20	Götz
533	NZ	Dugan	Apr. 19	R. I.
534	OA	Dugan	Apr. 19	R. I.
535	OC	Dugan	May 7	Dugan
536	OF	Peters	May 11	Strömgren
537	OG	Charlois	July 7	R. I.
538	OK	Götz	July 18	R. I.
539	OL	Wolf	Aug. 2	R. I.
540	ON	Wolf	Aug. 3	R. I.
541	OO	Wolf	Aug. 4	R. I.
542	OQ	Götz and Kopff	Aug. 15	R. I.
543	OT	Götz	Sept. 11	R. I.
544	OU	Götz	Sept. 11	R. I.
545	OY	Götz	Oct. 3	R. I.
546	PA	Götz	Oct. 10	R. I.
547	PB	Götz	Oct. 14	R. I.
548	PC	Götz	Oct. 14	R. I.
549	PK	Wolf	Nov. 15	R. I.
550	PL	Wolf	Nov. 16	R. I.
551	PM	Wolf	Nov. 16	R. I.
552	PO	Wolf	Dec. 14	R. I.
553	PP	Wolf	Dec. 27	R. I.

R. I. designates the Berlin Astronomical "Rechen-institute." No. 532 has been named Herculina.

VARIABLE STARS.

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.	
	d	h	d	h
T Vulpeculae	May 1	1	May 2	10
S Crucis	1	2	2	14
U Aquilae	1	5	3	9
U Vulpeculae	1	6	3	9
X Cygni	1	22	7	1
Y Sagittarii	2	7	4	9
W Virginis	2	22	4	9
U Sagittarii	3	2	6	1
R Triang. Austr.	3	15	4	15
δ Cephei	3	17	5	2
T Velorum	3	20	5	5
V Velorum	4	2	5	1
κ Pavonis	4	8	8	17
SU Cygni	4	11	5	19
RV Scorpii	4	14	5	23
η Aquilae	4	20	7	5
T Vulpeculae	5	11	6	20
R Crucis	5	12	6	21
ζ Geminorum	5	14	10	14
S Crucis	5	18	7	6
T Crucis	5	21	7	22
X Sagittarii	21	9	24	6
V Velorum	21	14	22	13
W Sagittarii	21	14	24	14
U Aquilae	22	6	24	10
T Velorum	22	10	23	19
κ Pavonis	22	12	26	21
RV Scorpii	22	18	24	3
R Crucis	22	23	24	8
T Vulpeculae	23	5	24	14
U Sagittarii	23	8	26	7
VY Cygni	23	12	25	14
SU Cygni	23	16	25	0
R Triang. Austr.	23	23	24	23
S Crucis	24	12	26	0
W Virginis	24	21	26	8
U Vulpeculae	25	4	27	7
δ Cephei	25	4	26	13
Y Sagittarii	25	9	27	11
Y Ophiuchi	25	14	31	19
ζ Geminorum	25	21	30	21
V Velorum	25	23	26	22
R Crucis	11	8	12	17
S Sagittae	11	14	15	0
η Aquilae	12	0	14	9
SU Cygni	12	3	13	11
T Crucis	12	14	14	15
V Velorum	12	20	13	19
T Velorum	13	3	14	12
β Lyrae	13	7	16	9
κ Pavonis	13	10	17	19
TX Cygni	13	13	18	16
V Carinæ	13	14	15	16
R Triang. Austr.	13	19	14	19
Y Sagittarii	13	20	15	22
W Virginis	13	22	15	9
W Geminorum	14	0	16	15
W Sagittarii	14	0	17	0
T Vulpeculae	14	8	15	17
X Sagittarii	14	9	17	6

	Minimum.		Maximum.	
	d	h	d	h
δ Cygni	May 14	11	May 15	20
S Crucis	15	3	16	15
U Aquilae	15	6	17	10
VY Cygni	15	15	17	17
ζ Geminorum	15	18	20	18
SU Cygni	15	23	17	7
W Geminorum	6	6	8	21
W Sagittarii	6	10	9	10
β Lyræ	6	20	10	3
V Carinae	6	22	9	2
R Triang. Austr.	7	0	8	0
T Monocerotis	7	1	14	23
X Sagittarii	7	9	10	6
VY Cygni	7	19	9	21
Y Sagittarii	8	1	10	3
U Aquilæ	8	5	10	9
SU Cygni	8	7	9	16
W Virginis	8	10	9	21
V Velorum	8	11	9	10
T Velorum	8	11	9	20
Y Ophiuchi	8	11	14	16
δ Cygni	9	2	11	11
U Vulpeculae	9	5	11	8
S Normae	9	13	13	22
U Sagittarii	9	20	12	19
T Vulpeculae	9	21	11	6
R Triang. Austr.	10	10	11	10
S Crucis	10	10	11	22
S Muscae	10	10	13	21
RV Scorpii	10	15	12	0
U Sagittarii	16	14	19	13
RV Scorpii	16	17	18	2
R Crucis	17	4	18	13
R Triang. Austr.	17	5	18	13
U Vulpeculae	17	5	19	8
W Virginis	17	7	25	11
T Velorum	17	18	19	3
X Cygni	18	8	23	11
T Vulpeculae	18	18	20	3
η Aquilae	19	4	21	13
S Normae	19	7	23	16
T Crucis	19	8	21	9
W Virginis	19	10	20	21
Y Sagittarii	19	14	21	16
β Lyræ	19	18	23	1
S Crucis	19	20	21	8
SU Cygni	19	20	21	4
δ Cygni	19	20	21	4
S Sagittae	20	0	23	10
S Muscae	20	3	23	14
V Carinae	20	7	22	11
R Triang. Austr.	20	14	21	14
T Crucis	26	1	28	3
β Lyræ	26	5	29	7
η Aquilae	26	9	28	18
V Carinæ	26	23	29	3
T Velorum	27	1	28	10
R Triang. Austr.	27	8	28	8
SU Cygni	27	13	28	21
T Vulpeculae	27	15	29	0

Variable Stars of Short Period not of the Algol Type.—(Continued.)

	Maximum.		Minimum.			Maximum.		Minimum.	
	d	h	d	h		d	h	d	h
TX Cygni	May 28	7	May 33	10	U Sagittarii	May 30	2	May 33	1
S Sagittae	28	9	31	19	V Velorum	30	8	31	7
X Sagittarii	28	9	31	6	W Virginis	30	9	31	20
R Crucis	28	19	30	4	δ Cephei	30	13	31	22
RV Scorpii	28	20	30	5	R Triang. Austr.	31	18	31	18
S Normae	29	1	33	10	Y Sagittarii	31	3	33	5
S Crucis	29	4	30	16	VY Cygni	31	8	33	10
W Sagittarii	29	5	32	5	SU Cygni	31	9	32	17
U Aquilae	29	7	31	11	T Velorum	31	16	33	1
S Muscae	29	18	33	5					

Approximate Magnitudes of Variable Stars Mar. 10, 1905.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.	Name.	R. A. 1900.		Decl. 1900.		Magn.
	h	m	°	′			h	m	°	′	
T Androm.	0	17.2	+26	26	10.4*d*	R Camelop.	14	25.1	+84	17	8.7 *i*
T Cassiop.	0	17.8	+55	14	8 *i*	R Bootis	14	32.8	+27	10	12.0*d*
R Androm.	0	18.8	+38	1	7 *i*	S Librae	15	15.6	−20	2	10.5*d*
S Ceti	0	19.0	− 9	53	*f*	S Serpentis	15	17.0	+14	40	*f*
S Cassiop.	1	12.3	+72	5	9.4*d*	S Coronae	15	17.3	+31	44	7 *i*
R Piscium	1	25.5	+ 2	22	13.5*d*	S Urs. Min.	15	33.4	+78	58	10 *d*
U Persei	1	52.9	+54	20	11.5*d*	R Coronae	15	44.4	+28	28	6
R Arietis	2	10.4	+24	36	11.2*d*	V "	15	45.9	+39	52	9.5 *i*
o Ceti	2	14.3	− 3	26	3.8*d*	R Serpentis	15	46.1	+15	26	12 *d*
S Persei	2	15.7	+58	8	8.7 *i*	R Herculis	16	1.7	+18	38	*f*
R Ceti	2	20.9	− 0	38	9.3*d*	R Scorpii	16	11.7	−22	42	*f*
U "	2	28.9	−13	35	9.5*d*	S "	16	11.7	−22	39	*f*
R Trianguli	2	31.0	+33	50	8.6 *i*	U Herculis	16	21.4	+19	7	8.8 *i*
R Persei	3	23.7	+35	20	13 *d*	W Herculis	16	31.7	+37	32	12.5*d*
R Tauri	4	22.8	+ 9	56	11.5*d*	R Draconis	16	32.4	+66	58	12.5*d*
S "	4	23.7	+ 9	44	10.0	S Herculis	16	47.4	+15	7	*f*
R Aurigæ	5	9.2	+53	28	8.0 *i*	R Ophiuchi	17	2.0	−15	58	*s*
U Orionis	5	49.9	+20	10	9.8 *i*	T Herculis	18	5.3	+31	0	8.5 *i*
R Lyncis	6	53.0	+55	28	12 *d*	R Scuti	18	42.2	− 5	49	*s*
R Gemin.	7	1.3	+22	52	13 *d*	R Aquilae	19	1.6	+ 8	5	9 *i*
S Canis Min.	7	27.3	+ 8	32	8.5*d*	R Sagittarii	19	10.8	−19	29	*s*
R Cancri	8	11.0	+12	2	10.6*d*	S "	19	13.6	−19	12	*s*
V "	8	16.0	+17	36	9.5*d*	R Cygni	19	34.1	+49	58	8.5*d*
S Hydrae	8	48.4	+ 3	27	11.5*d*	RT "	19	40.8	+48	32	10.5*d*
T "	8	50.8	− 8	46	11.0*d*	X "	19	46.7	+32	40	7.5*d*
R Leo. Min.	9	39.6	+34	58	10.5*d*	S "	20	3.4	+57	42	*s*
R Leonis	9	42.2	+11	54	8.5 *i*	RS "	20	9.8	+38	28	7.5
R Urs. Maj.	10	37.6	+69	18	*f*	R Delphini	20	10.1	+ 8	47	*u*
R Comae Ber.	11	59.1	+19	20	12.5*d*	U Cygni	20	16.5	+47	35	11 *d*
T Virginis	12	9.5	− 5	29	11.0*d*	V "	20	38.1	+47	47	*s*
R Corvi	12	14.4	−18	42	9.5*d*	T Aquarii	20	44.7	− 5	31	*s*
Y Virginis	12	28.7	− 3	52	*f*	R Vulpec.	20	59.9	+23	26	9 *d*
T Urs. Maj.	12	31.8	+60	2	7.2	T Cephei	21	8.2	+68	5	6.5 *i*
R Virginis	12	33.4	+ 7	32	8.0 *i*	S "	21	36.5	+78	10	9.2 *i*
S Urs. Maj.	12	39.6	+61	38	9.7*d*	S Lacertae	22	24.6	+39	48	9 *d*
U Virginis	12	46.0	+ 6	6	11.4*d*	R "	22	38.8	+41	51	*u*
V "	13	22.6	− 2	39	*f*	S Aquarii	22	51.8	−20	53	*s*
R Hydrae	13	24.2	−22	46	6.0 *i*	R Pegasi	23	1.6	+10	0	12.5*d*
S Virginis	13	27.8	− 6	41	11.5*d*	S "	23	15.5	+ 8	22	10.5*d*
R Can. Ven.	13	44.6	+40	2	10.1 *i*	R Aquarii	23	38.6	+15	50	6 *i*
S Bootis	14	19.5	+54	16	*f*	R Cassiop.	23	53.3	+50	50	9.4 *i*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that the light is increasing; *d*, that the light is decreasing; *s*, that it is near the Sun; and *u*, that its magnitude is unknown.

From observations made at the McCormick, Vassar College, Mt. Holyoke College and Harvard Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc.

U Cephei.

	d	h
May	3	9
	5	21
	8	9
	10	21
	13	8
	15	20
	18	8
	20	21
	23	8
	25	20
	28	7
	30	19

R Canis Maj.

	d	h
May	1	17
	2	21
	4	0
	5	3
	6	6
	7	10
	8	13
	9	16
	10	19
	11	22
	13	2
	14	5
	15	8
	16	12
	17	15
	18	18
	19	21
	21	1
	22	4
	23	7
	24	11
	25	14
	26	17
	27	20
	29	0
	30	3
	31	6

Y Camelopard.

	d	h
May	1	12
	4	20
	8	3
	11	10
	14	18
	18	1
	21	8
	24	16
	27	23
	31	6

RR Puppis.

	d	h
May	4	5
	10	15

RR Puppis.

	d	h
May	17	1
	23	12
	29	22

V Puppis.

	d	h
May	1	7
	2	18
	4	5
	5	16
	7	3
	8	14
	10	1
	11	12
	12	22
	14	9
	15	20
	17	7
	18	18
	20	5
	21	16
	23	3
	24	14
	26	1
	27	12
	28	22
	30	9
	31	20

S Cancri.

	d	h
May	6	16
	16	4
	25	15

S Antliæ.

Period 7h 46m.8

	d	h
May	1	20
	2	19
	3	19
	4	18
	5	17
	6	17
	7	16
	8	15
	9	15
	10	14
	11	13
	12	13
	13	12
	14	11
	15	11
	16	10
	17	9
	18	9
	19	8
	20	7
	21	7
	22	6

S Antliæ.

	d	h
May	23	5
	24	5
	25	4
	26	3
	27	3
	28	2
	29	1
	30	1
	31	0
	31	23

S Velorum.

	d	h
May	1	9
	7	7
	13	5
	19	4
	25	2
	31	1

W. Urs. Maj.

May	1-4	14h
	5-31	15

RR Velorum.

	d	h
May	2	16
	4	12
	6	9
	8	5
	10	2
	11	22
	13	19
	15	15
	17	12
	19	8
	21	5
	23	1
	24	22
	26	18
	28	15
	30	11

Z Draconis.

	d	h
May	1	10
	2	19
	4	3
	5	12
	6	21
	8	5
	9	14
	10	22
	12	7
	13	16
	15	0
	16	9
	17	17
	19	2

Z Draconis.

	d	h
May	20	10
	21	19
	23	4
	24	12
	25	21
	27	5
	28	14
	29	22
	31	7

δ Libræ.

	d	h
May	2	19
	5	3
	7	11
	9	19
	12	3
	14	11
	16	19
	19	2
	21	10
	23	18
	26	2
	28	10
	30	18

U Coronæ.

	d	h
May	2	21
	6	8
	9	19
	13	6
	16	17
	20	4
	23	14
	27	1
	30	12

R Aræ.

	d	h
May	1	22
	6	9
	10	19
	15	5
	19	15
	24	1
	28	12

U Ophiuchi.

	d	h
May	1	11
	2	7
	3	3
	4	0
	4	20
	5	16
	6	12
	7	8
	8	4
	9	0
	9	21

U Ophiuchi.

	d	h
May	10	17
	11	13
	12	9
	13	5
	14	1
	14	21
	15	17
	16	14
	17	10
	18	6
	19	2
	19	22
	20	18
	21	14
	22	10
	23	7
	24	3
	24	23
	25	19
	26	15
	27	11
	28	7
	29	3
	30	0
	30	20
	31	16

Z Herculis.

	d	h
May	1	8
	3	5
	5	7
	7	4
	9	7
	11	4
	13	7
	15	4
	17	7
	19	4
	21	7
	23	4
	25	7
	27	4
	29	6
	31	3

RS Sagittarii.

	d	h
May	1	17
	4	3
	6	13
	8	23
	11	9
	13	19
	16	5
	18	15
	21	1
	23	11
	25	21
	28	7
	30	17

Minima of Variable Stars of the Algol Type.—Continued.

V Serpentis.

	d	h
May	2	9
	5	20
	9	7
	12	18
	16	5
	19	16
	23	3
	26	13
	30	0

RX Herculis.

	d	h
May	1	14
	2	11
	3	8
	4	6
	5	3
	6	0
	6	22
	7	19
	8	16
	9	14
	10	11
	11	8
	12	6
	13	3
	14	0
	14	22
	15	19
	16	16
	17	14
	18	11
	19	8
	20	6

RX Herculis.

	d	h
May	21	3
	22	1
	22	22
	23	19
	24	17
	25	14
	26	11
	27	9
	28	6
	29	3
	30	1
	30	22
	31	19

RV Lyræ.

	d	h
May	2	4
	5	19
	9	9
	12	23
	16	14
	20	4
	23	19
	27	9
	30	23

U Sagittæ.

	d	h
May	2	4
	5	13
	8	22
	12	7
	15	17
	19	2
	22	11
	25	20
	29	5

SY Cygni.

	d	h
May	3	3
	9	3
	15	3
	21	3
	27	3

WW Cygni.

	d	h
May	2	1
	5	9
	8	17
	12	0
	15	8
	18	16
	21	23
	25	7
	28	14
	31	22

SW Cygni.

	d	h
May	2	8
	6	21
	11	11
	16	1
	20	15
	25	4
	29	18

VW Cygni.

	d	h
May	6	15
	15	1
	23	11
	31	22

UW Cygni.

	d	h
May	1	10
	4	21
	8	8
	11	19
	15	5
	18	16
	22	3
	25	14
	29	1

W Delphini.

	d	h
May	1	7
	6	2
	11	4
	15	17
	20	12
	25	8
	30	3

Y Cygni.

	d	h
May	2	7
	3	16
	5	6
	6	16
	8	6
	9	16
	11	6
	12	16
	14	6
	15	16
	17	6
	18	16
	20	6
	21	16

Cygni.

	d	h
May	23	6
	24	16
	26	6
	27	16
	29	6
	30	16

VV Cygni.

	d	h
May	1	19
	3	6
	4	18
	6	5
	7	17
	9	4
	10	15
	12	3
	13	14
	15	2
	16	13
	18	1
	19	12
	21	0
	22	11
	23	22
	25	10
	26	21
	28	9
	29	20
	31	8

UZ Cygni.

	d	h
May	29	20

Maxima of UY Cygni.

Period $13^h\ 27^m\ 27^s.59$. The minimum occurs $1^h\ 55^m$ before the maximum.

	d	h
May	1	11
	2	14
	3	17
	4	20
	5	23
	7	2
	8	4

	d	h
May	9	7
	10	10
	11	13
	12	16
	13	19
	14	22
	16	1

	d	h
May	17	4
	18	7
	19	10
	20	12
	21	15
	22	18
	23	21

	d	h
May	25	0
	26	3
	27	6
	28	9
	29	12
	30	15
	31	18

Maxima of RZ Lyræ.

Period $12^h\ 16^m\ 15^s.0$.

	d	h
May	1	1
	2	2
	3	2
	4	3
	5	3
	6	4
	7	4
	8	5

	d	h
May	9	6
	10	6
	11	7
	12	7
	13	8
	14	8
	15	9
	16	9

	d	h
May	17	10
	18	10
	19	11
	20	11
	21	12
	22	12
	23	13
	24	13

	d	h
May	25	14
	26	14
	27	15
	28	15
	29	16
	30	16
	31	17

Maxima of Y Lyræ.

Period $12^h\ 03^m.9$. The minimum occurs $1^h\ 40^m$ before the maximum.

	d	h		d	h		d	h		d	h
May	1-8	5	May	9-15	6	May	16-23	7	May	24-31	8

New Variables 39.1905 Draconis and 40.1905 Camelopardalis.—These are announced by Professor W. Ceraski in *A. N.* 4000 and were discovered by Mme. L. Ceraski on the photographs taken at Moscow by M. S. Blajko. Their positions are as follows:

	R.A. 1855.0			Decl. 1855.0		R.A. 1900.0			Decl. 1900.0	
	h	m	s	°	′	h	m	s	°	′
39.1905 = BD. + 74.788	18	41	25	+74	11.4	18	40	14	+74	14.0
40.1905 = BD. + 72.275	5	17	59	+72	20.2	5	23	24	+72	22.8

The first star is given in the BD. as of magnitude 9.2. The photographs indicate a variation between 9.5 and 11.5 in a period of about three months.

The second star is rated at 9.5^m in the BD. while the photographs indicate a variation between 9.5 and 10.5. The period cannot yet be derived but is perhaps about five months.

105 New Variable Stars in Scorpius.—The investigation of large nebulous regions, described in *Circulars* Nos. 78, 79, 82, and 86, has been continued by Miss Henrietta S. Leavitt, with the results given in this *Circular*.

In no respect has the results of photography been more striking than in the revelation of diffused nebulæ of vast extent whose faintness renders them almost beyond the reach of visual observation. One of the most remarkable of these extends over many square degrees in the constellations of Scorpius and Ophiuchus. Like the Nebula of Orion, it attaches itself to the individual stars, the principal condensation being about the quadruple star, ρ Ophiuchi. The region is marked by a noticeable absence of stars of the fainter magnitudes, and dark lanes can be traced in different directions for a considerable distance beyond the visible nebulosity. A cursory examination of a part of this region has led to the discovery of seventy-two new variable stars, besides the known variables, R, S, W, X, Y, RX and RZ Scorpii, and No. 1 in the cluster N.G.C. 6093. The position, R. A. = $16^h\ 23^m\ 39^s$, Dec. = $-19°\ 7'.1$ (1900), does not differ greatly from R. A. = $16^h\ 23^m\ 49^s$, Dec. = $-19°\ 13'.3$ (1900), which is that given for Y Scorpii by its discoverer, Dr. Peters. As Hartwig states that the position of Y Scorpii is uncertain, it is assumed that the two positions refer to the same object. Thirty-three plates were examined. Of these twenty-six were taken with the 24-inch Bruce Telescope, with exposures of from 60 to 273 minutes, and seven were taken with the 8-inch Bache Telescope, with exposures of from 45 to 150 minutes. In the region extending in right ascension from about $16^h\ 0^m$ to $16^h\ 20^m$, and in declination from about $-18°$ to $-23°$, it is improbable that any large number of variables, which at maximum are brighter than the fourteenth magnitude, have been overlooked. The region extending in right ascension from about $16^h\ 25^m$ to $16^h\ 45^m$, and in declination from about $-25°$ to $-30°$, has also been fairly well covered, especially in the following portion. A few variables outside of the above limits are in regions for which there was but little material available for examination.

In Table I, the successive columns give a number for reference, the right ascension and declination for 1900, the brightest and faintest observed magnitudes, according to a provisional scale, and the range.

TABLE I.

VARIABLE STARS IN SCORPIUS.

No.	R. A. 1900. h	m	s	Dec. 1900. °	′	Br.	Ft.	R.
1	15	57	34	−23	18.4	12.8	<15.0	2.2
2	16	1	6	−21	54.0	13.5	14.4	0.9
3	16	1	10	−23	24.0	12.9	14.0	1.1
4	16	1	45	−23	2.6	11.3	14.5	3.2
5	16	1	52	−23	47.6	12.3	13.9	1.6
6	16	2	35	−21	49.1	12.4	14.2	1.8
7	16	3	42	−21	37.9	13.0	13.6	0.6
8	16	4	18	−22	27.3	11.8	13.3	1.5
9	16	4	27	−23	50.4	11.2	13.1	1.9
10	16	4	52	−22	48.2	10.7	14.8	4.1
11	16	6	7	−19	40.3	13.0	14.2	1.2
12	16	6	36	−20	40.4	11.4	12.2	0.8
13	16	8	46	−21	27.1	11.2	14.3	3.1
14	16	9	8	−21	30.6	11.1	12.1	1.0
15	16	9	37	−24	46.0	12.3	15.5	3.2
16	16	9	38	−22	28.1	11.2	12.8	1.6
17	16	10	10	−23	21.3	12.3	13.7	1.4
18	16	10	58	−21	24.8	12.9	13.6	0.7
19	16	12	11	−21	34.6	13.4	<15.0	1.6
20	16	12	22	−20	57.4	12.4	14.2	1.8
21	16	13	28	−22	7.0	11.8	<15.0	3.2
22	16	13	42	−23	10.0	10.8	12.3	1.5
23	16	14	36	−23	0.2	12.9	14.1	1.2
24	16	15	2	−21	17.4	11.7	12.4	0.7
25	16	15	32	−21	53.1	11.6	12.3	0.7
26	16	15	48	−22	39.1	13.6	14.7	1.1
27	16	16	42	−20	44.3	13.3	14.7	1.4
28	16	18	14	−22	16.0	12.3	12.8	0.5
29	16	19	21	−24	15.9	12.5	12.9	0.4
30	16	20	43	−22	5.6	12.9	<15.5	2.6
31	16	20	50	−22	0.3	13.0	13.8	0.8
32	16	21	1	−31	4.7	10.6	<14.7	4.1
33	16	22	6	−21	22.1	12.1	13.0	0.9
34	16	22	21	−21	32.8	12.0	12.9	0.9
35	16	23	8	−29	48.3	13.8	14.7	0.9
36	16	23	13	−20	1.0	12.4	13.5	1.1
37	16	25	28	−27	41.7	12.2	<13.6	1.4
38	16	26	40	−26	10.4	11.8	<15.0	3.2
39	16	27	13	−25	58.6	11.8	13.7	1.9
40	16	27	38	−26	32.2	12.2	14.8	2.6
41	16	28	2	−26	24.2	11.7	13.1	1.4
42	16	29	4	−26	16.5	11.2	15.0	3.8
43	16	30	41	−29	31.8	12.8	<15.0	2.2
44	16	30	52	−27	6.5	12.2	<15.0	2.8
45	16	31	12	−27	53.6	13.7	<15.0	1.3
46	16	31	32	−29	6.9	13.2	14.2	1.0
47	16	31	58	−28	22.0	10.5	<15.0	4.5
48	16	32	37	−27	49.4	13.5	<15.0	1.5
49	16	34	48	−27	15.9	10.9	<14.5	3.6
50	16	36	37	−24	34.2	10.5	12.0	1.5
51	16	38	16	−27	49.9	13.1	14.1	1.0
52	16	38	42	−24	55.6	11.2	12.8	1.6
53	16	38	46	−28	43.2	13.6	14.5	0.9
54	16	39	1	−26	41.5	12.6	13.8	1.2
55	16	39	30	−28	1.7	10.9	13.0	2.1
56	16	39	43	−29	31.9	13.6	14.9	1.3
57	16	40	23	−27	12.4	10.7	14.8	4.1
58	16	40	25	−29	57.5	13.8	<14.8	1.0
59	16	40	29	−27	56.8	13.6	<14.8	1.2
60	16	41	6	−30	15.7	12.5	13.5	1.0

No.	R. A. 1900. h	m	s	Dec. 1900. °	′	Br.	Ft.	R.
61	16	41	8	−28	1.9	14.2	14.8	0.6
62	16	41	15	−29	25.3	13.9	14.5	0.6
63	16	42	12	−29	56.9	12.8	13.8	1.0
64	16	43	5	−27	2.6	13.0	<15.0	2.0
65	16	43	36	−27	16.2	13.7	14.9	1.2
66	16	43	36	−29	24.1	11.3	11.8	0.5
67	16	43	56	−28	17.2	10.9	<14.7	3.8
68	16	44	4	−27	49.6	13.0	14.0	1.0
69	16	44	9	−28	1.2	13.6	14.5	0.9
70	16	44	17	−25	23.4	10.9	<15.0	4.1
71	16	44	38	−27	47.6	13.8	14.8	1.0
72	16	46	18	−28	22.8	12.2	<15.0	2.8

REMARKS.

No. 10. This star is C. DM. — 22° 11391.

No. 29. In a strongly nebulous region. Variation well seen, though small.

No. 36. The variation, although well seen, is less marked than the estimated magnitudes would indicate. The variable is near the edge of the plates, and difficult to observe.

No. 38. A star of about the magnitude 14.5 precedes the variable about 1ˢ.5, and is south of it about 0′.8.

No. 39. The northern and preceding of two stars.

No. 49. This star is C. DM. — 27° 11069.

No. 50. This star is C. DM. — 24° 12774.

No. 55. The following of two stars.

No. 66. Variation well seen, though small.

No. 69. The central star of a line of three having nearly the same declination.

No. 72. A star of the fifteenth magnitude is about 2ˢ following, and 0′.7 north.

Nos. 7, 11, 17, 18, 26, 27, and 62, are apparently variable stars of short period, but the majority of the others will perhaps be found to have long periods. These variables are, in general, brighter at maximum than those announced in *Circulars* Nos. 78, 79, and 82. The range of variation is greater, twenty-one showing changes of two magnitudes or more. It cannot be determined whether many of these variable stars are directly connected with the nebula, as only one of them, No. 29, is in a strongly nebulous region. Very few faint stars are seen in such regions, excepting on one plate, which was exposed for 273 minutes.

An open and rather irregular globular cluster, Messier 4 (N.G.C. 6121), is situated at the edge of the nebula, near α Scorpii. Two variable stars were discovered in it during the general examination of the region, and seven others were noticed while these were being observed. This led to a careful examination of the cluster, by Professor Bailey's method, as described in Volume XXXVIII of the *Annals*. Eight plates, four of which were taken with the 24-inch Bruce Telescope, and four with the 8-inch Bache Telescope, were used. Within a radius of fifteen minutes from the center of the cluster, in an area of 706 square minutes, 334 stars were counted, and 32 variables found besides No. 33, which is seventeen minutes from the center. Five other stars are suspected, and will probably be confirmed as variable when additional photographs can be examined. These variables and several catalogue stars are given in Table II. The first two columns give the designation and the number in the Cordoba *Durchmusterung*. In the third and fourth columns are given the cöordinates referred to the assumed center of the cluster, and expressed in seconds of arc. They depend upon eye estimates, but are probably correct within three seconds of arc. No correction has been made for the scale and orientation of the enlargement used. These, however, may be determined from the catalogue stars. The last three columns give the brightest and faintest observed magnitudes, and the range.

TABLE II.

VARIABLE STARS IN N.G.C. 6121.

Des.	Cat. No.		x	y	Br.	Ft.	R.
	°		″	″			
A	−26	11305	−379	−1053	..	..	..
B	−26	11310	−152	+ 564	..	..	..
C	−26	11316	+ 61	− 204	..	..	..
D	−25	11495	+184	+ 924	..	..	..
E	−26	11329	+881	−1029	..	..	..
1	..	..	−281	+ 42	13.0	13.5	0.5
2	..	..	−248	− 195	13.0	13.9	0.9
3	..	..	−208	− 507	12.6	13.6	1.0
4	−26	11309	−185	− 340	10.7	12.0	1.3
5	..	..	−185	− 93	13.1	13.4	0.3
6	..	..	−115	+ 318	13.1	13.5	0.4
7	..	..	−113	+ 231	12.9	13.8	0.9
8	..	..	−110	+ 111	13.0	13.7	0.7
9	..	..	−104	+ 105	13.1	13.7	0.6
10	..	..	− 68	+ 159	12.7	13.7	1.0
11	..	..	− 64	− 297	12.0	13.4	1.4
12	..	..	− 53	− 207	12.7	13.9	1.2
13	..	..	− 47	+ 270	12.0	12.6	0.6
14	..	..	− 47	− 244	13.1	14.2	1.1
15	..	..	− 32	+ 436	12.7	13.7	1.0
16	..	..	− 29	+ 69	12.8	13.8	1.0
17	..	..	− 8	+ 20	13.2	13.7	0.5
18	..	..	+ 4	+ 27	13.0	13.7	0.7
19	..	..	+ 11	+ 358	12.6	13.6	1.0
20	..	..	+ 13	− 63	13.0	13.4	0.4
21	..	..	+ 19	− 4	13.0	13.7	0.7
22	..	..	+ 34	+ 80	13.1	13.7	0.6
23	..	..	+ 38	− 26	12.9	13.4	0.5
24	..	..	+ 49	+ 48	12.4	13.9	1.5
25	..	..	+ 70	+ 70	12.9	13.6	0.7
26	..	..	+ 94	− 72	12.1	13.7	1.6
27	..	..	+118	+ 255	12.7	13.7	1.0
28	..	..	+259	+ 84	12.9	13.5	0.6
29	..	..	+326	+ 598	12.4	13.7	1.3
30	..	..	+340	− 69	13.0	13.5	0.5
31	..	..	+353	+ 45	11.9	13.5	1.6
32	..	..	+746	− 40	12.6	13.5	0.9
33	..	..	+805	+ 630	12.5	13.2	0.7

Harvard Circular No. 90. EDWARD C. PICKERING.

Sixteen New Variable Stars in Sagittarius.—The Trifid Nebula is near the centre of a large number of the plates taken for the study of Phoebe, the ninth satellite of Saturn. A careful search for variable stars in this interesting region has been made by Miss Leavitt. Seventeen plates taken with the 24-inch Bruce Telescope, and having exposures of from one to three hours, have been examined. The extent of the region covered has been increased by the use of fourteen plates, taken with the 8-inch Bache Telescope, and having exposures of from forty-five to sixty minutes. There seems to be no evidence that variable stars are present in large numbers in this region.

In the table the successive columns give a current number, the right ascension for 1900, the declination for 1900, the brightest magnitude, the faintest magnitude, and the range of variation.

VARIABLE STARS IN SAGITTARIUS.

No.	R. A. 1900. h	m	s	Dec. 1900. °	′	Br.	Ft.	R.
1	17	46	3	−22	35.3	12.0	14.7	2.7
2	17	47	8	−21	44.6	12.2	14.7	2.5
3	17	49	6	−21	43.5	12.6	13.9	1.3
4	17	51	8	−19	19.5	10.5	<14.5	4.0
5	17	54	22	−21	7.7	12.1	13.6	1.5
6	17	57	16	−26	28.6	11.0	12.3	1.3
7	17	58	24	−22	57.5	13.4	14.5	1.1
8	17	58	45	−22	44.1	10.9	12.0	1.1
9	18	2	1	−22	14.1	9.5	11.9	2.4
10	18	2	20	−22	57.3	13.7	14.6	0.9
11	18	2	24	−23	4.8	14.0	51.1	1.1
12	18	6	7	−20	43.4	10.9	12.8	1.9
13	18	8	44	−29	44.2	10.6	12.1	1.5
14	18	16	49	−27	28.4	11.5	<13.0	1.5
15	18	17	26	−18	37.4	10.4	11.4	1.0
16	18	17	46	−30	38.8	10.6	12.0	1.4

REMARKS.

5. Probably of the Algol type. Brightness uniform on twenty-two out of twenty-six plates examined.

7. Probably of the Algol type. Brightness uniform on eighteen out of twenty plates examined.

9. This is − 22° 4575, and the preceding of two stars.

11. The preceding of two stars. Probably of the Algol type. Brightness uniform on eighteen out of twenty plates examined.

13. This is C. DM. −29° 14717.

16. This is C. DM. −30° 15642.

The total number of new variables discovered by Miss Leavitt and announced in Circulars Nos. 78, 79, 82, 86, 90, and 91, is 410.

Harvard Circular No. 91. EDWARD C. PICKERING.

GENERAL NOTES.

We have received a copy of Dr. Elkins' work entitled a Revision of the First Yale Triangulation of the principal stars of the Pleiades by the aid of the heliometer. We have read this paper through very carefully, and have found it so interesting that we hope soon to give an abstract of it, with such illustration, as may aid in giving a clear idea of its principal points and conclusions.

The Great February Sun-Spot.—We have been favored with a brief article and a drawing of the great sun-spot of February last by Th. Moreux of Bourges Observatory, France. The original drawing was ten inches by eight and it is a fine representation of what was seen Feb. 3 when it was made. The reproduction of it in the frontispiece is quite satisfactory. The very fine screen that was used in making the half-tone gives the best copy of drawing that can be made by that process.

The Equinoxes of the Planets.—One reader of POPULAR ASTRONOMY is very anxious for information regarding the respective times when the planets Mercury, Venus, Mars, Jupiter, Saturn and Uranus will be at their equinoxes. By this query he means the respective times when the days and nights of each planet are equal. Perhaps some of our readers would like to answer this very unusual query after astronomical information. A correct answer, we think, would satisfy the curiosity and the interest of practical astronomers if they ever have such conditions of mind in this matter.

The Figure of the Earth.—The leading article in the February *Bulletin Astronomique* (French) by M. P. Rudzki is concerning the determination of the figure of the Earth from the measures of gravitation at different places on the surface of the Earth. This extended article on this live question in theoretical astronomy is timely. We have not noticed recently any thorough mathematical discussion of this theme in English. Will some practical astronomer give us information on this point, if there is any to give?

Observations of Comet *e* 1904 (Borrelly).—*Bulletin* No. 4, from Laws Observatory, University of Missouri gives a series of twelve observations of Comet *e*, 1904 (Borrelly) between Dec. 31, 1904 and Feb. 6, 1905. They were made by Director Seares and will be useful for a definitive orbit.

One Hundred New Double Stars.—Some time ago we received the eighth catalogue of one hundred new double stars discovered by R. G. Aitken by the aid of the 12-inch and the 36-inch refractors of Lick Observatory, Mount Hamilton, California. Mr. Aitken says that nearly half of these double stars were discovered with the 12-inch telescope, but with few exceptions the measures given in the catalogue were made with the 36-inch refractor. The list includes fifteen stars whose components are less than 0.″25 apart, and only twenty with components that are more than 2″.00 apart. As far as we know Mr. Aitken is clearly in the lead, in the recent discovery of double stars, by vernal means, in this country if not in every other one. By experts in this branch his measures are said to be thoroughly reliable.

School Science and Mathematics for March presents an array of names in its editorial board that is almost startling, an editor-in-chief, six department editors and twenty-nine associates. Its size is largely increased and its leading articles are of high grade in quality. There is a very useful field for this magazine because the staunch work it may do is terribly needed now in the United States in the secondary schools. The Middle States and the West are going too far in harmful changes in the required courses in mathematics for entrance to college. In an article elsewhere published in this number it very clearly and very well sounds a timely warning.

The Solar Observatory of the Carnegie Institution at Mt. Wilson, California.—In the March number of the *Astrophysical Journal*, Professor Hale has given a full description of the new Solar Observatory of the Carnegie Institution at Washington, D. C., which is located on Mt. Wilson, California. At the annual meeting of the board of trustees a grant of $150,000 was authorized for use in 1905. This amount is probably not one half of the money to be expended in the first equipment.

The article gives information of the work to be done by the new Observatory, illustrations of some of the instruments, the mountings, the location and its attractive surroundings. The staff of the observatory so far selected is as follows: George E. Hale, Director; G. W. Ritchey, Astronomer and Supt. of Instrument Construction; F. Ellerman and Walter S. Adams, Assistant Astronomers.

In a recent letter from Professor Hale, he adds the further fact, that since the article referred to was written, the mirrors have been put into the the Snow telescope, and it has been found to the great satisfaction of all, that the definition of the solar image is excellent. Later we hope to give a fuller account of what is going on at this new observatory on Mt. Wilson.

Changes Near Thoth and Amenthes on Mars.—On March 9, 1905, a telegram was received at Harvard College Observatory from Percival Lowell, of Lowell Observatory, Flagstaff, Arizona, that functional alterations in the vicinity of Thoth and Amenthes on the planet Mars have again been observed at that Observatory. Both these canals are double. We do not remember that Mr. Lowell has called attention to the doubling of these canals before.

The 24-Inch Reflecting Telescope.—One of the most important results obtained with the Anonymous Fund of 1902 has been the construction of the 24-inch Reflecting Telescope. The mirror was made by Messrs. Alvan Clark & Sons, and the mounting has been designed and constructed by Mr. Willard P. Gerrish of this Observatory. Although the mounting is not completed, yet it is so far advanced that the telescope can be used for visual work, and is giving excellent results in determining the light of faint stars. Accordingly, measures have been made by Mr. Leon Campbell of three of the variable stars discovered by Miss Leavitt, Nos. 91, 93, and 94, near the Nebula of Orion, and announced in *Circular* No. 86. The dates of observation, the magnitudes derived for No. 91 from observations by the writer with the 12-inch Meridian Photometer, and the magnitudes of Nos. 91, 93, and 94, as determined with the 24-inch, are given in the successive columns of Table I.

TABLE I.

OBSERVATIONS OF VARIABLES.

Date.	12-inch.	24-inch.		
1905.	91	91	93	94
January 28	..	10.8	13.0	13.5
" 30	..	10.4	13.0	13.5
" 31	..	10.7	12.9	13.6
February 2	..	10.8	12.8	13.6
" 3	..	10.9	12.6	13.6
" 4	..	11.2	12.5	R
" 7	..	11.7	12.7	13.4
" 11	..	10.6	12.9	13.0
" 13	10.8	10.6	..	..
" 14	10.8	10.8	..	..
" 16	10.9	10.7	..	..
" 18	10.8	..	..	..
" 21	10.9	10.9	..	..
" 23	..	11.1	..	..
" 25	11.7	11.4	R	12.4
" 27	11.4	11.5	13.1	12.7
" 28	11.5	11.3	12.9	12.8
March 1	..	11.1	12.5	12.9
" 2	11.0	10.9	12.9	12.7
" 3	10.8	10.7	13.0	12.8
" 4	..	10.7	12.7	13.0
" 11	..	11.0	14.0	1.24

While the variability of all three stars is thus confirmed, the absolute magnitudes of the fainter stars are uncertain. On February 4, 1905, No. 94 was not visible, and was certainly fainter than the magnitude 13.6. On February 22, No. 93 was certainly fainter than 13.2. The Moon prevented observations of Nos. 93 and 94, from February 13 to February 23. As these stars are within 40″ of each other, and are usually alternately bright and faint, it seemed probable that the period was the same for both, and that some connection existed between them. On one photograph, however, both stars appear bright, so probably the periods differ slightly.

Harvard Circular No. 93. EDWARD C. PICKERING.

Annals of the Astronomical Observatory of the Imperial University of Krakow.—The first volume of this observatory giving details of the Repsold Meridian Circle work is at hand. Also two publications from the same source, No. 4, 1897, and No. 5, 1904, which are studies of the Sun's surface.

Jupiter's Seventh Satellite.—Astronomer C. D. Perrine of Lick Observatory has discovered a seventh satellite belonging to the planet Jupiter. Its position on February 25, 600 G. M. T., was as follows:

Position angle 62°, distance 21′. The daily motion is 60″ southeast, magnitude 16. Apparent motion is direct with large inclination to the ecliptic. The object appears on photographs taken with the Crossley Reflector since Jan. 2.

We were informed, March 9, by Harvard College Observatory, that Rear Admiral C. M. Chester, Supt. of the United States Naval Observatory, Washington, D. C., had communicated the following information:—On the night of Jan. 8, 1905, search was made for the sixth satellite of Jupiter with the 26-inch equatorial, by assistant astronomer Hammond. A very faint object was seen in the position computed from the Lick Observatory telegrams which was proven to be the satellite by its motion with regard to a neighboring star.

Jacoby's Tables for the Reduction of Astronomical Photographs.—In 1895 Professor Jacoby of Columbia University and, in the absence of Professor J. K. Rees, the Acting Director of the observatory, published a paper entitled: "On the Reduction of Stellar Photographs with Special Reference to the Astro-Photographic Catalogue plates." The method in that paper was intended primarily for the reduction of a great number of plates made in the same declination. But photographs intended for star-cluster catalogues, solar or stellar parallax and other similar ones usually involve so few plates of a single declination that it is not economical to prepare the kind of special tables suitable for a photographic catalogue of the heavens.

For this reason Mr. Jacoby has modified his method and added tables suitable for the reduction of isolated groups of plates made at any declination more than 15° from the pole.

For a knowledge of the details of this interesting publication readers are referred to the paper itself. It is No. 23 of the Contributions from the Observatory of Columbia University, with the particular title given above.

Total Solar Eclipse Aug. 29-30, 1905.—We have received a large map of the path of the total eclipse of the Sun Aug. 29-30, which has been prepared under the direction of the Bureau of Longitudes at Paris and published by Gautier Villars of the same place. This map is by far the most complete that we have seen up to the present time. It covers a great part of Europe and northern Africa including the Red Sea. Curved red lines indicate the progress of the beginning of the eclipse for every five minutes throughout its entire path. In the same way broken red lines show the progress of the shadow at its end. The path of totality appears to be drawn to scale in regard to its width which measures approximately two hundred miles.

The partial phases north and south of the zone of totality are indicated by black curved lines drawn parallel, at a distance from one another to show zones of obscuration that differ by one digit, or one-twelfth of the Sun's diameter. This map will be very useful in preparing to observe the coming eclipse.

Earth's Heat Caused by Radium.—In a recent number of Harper's Magazine occurs an article by Professor E. Rutherford suggesting that the new element, radium, may possibly be considered as a source if not the source of heat from within the Earth. In that article this paragraph occurs: "Since one gram of radium emits enough heat each hour to raise one hundred grams of water through 1° C., a simple calculation shows that the present loss of heat from the Earth is equivalent to that supplied by the presence of about 270 million tons of radium. This amount may seem very large compared with the small quantities of radium hitherto separated, but is small, for example, compared with the annual output of coal for the world. It can be readily deduced that this amount of radium if distributed throughout the Earth's crust, corresponds to only five parts in one hundred million million per unit mass. This is a very small quantity, and calculations based on the observations of Elster and Geitel show that the radio-activity observed in soils corresponds to the presence of about this proportion of radium.

Meeting of the British Association in South Africa.—From a recent issue of the *Cape Times* we notice that a meeting of the British Association in South Africa is already planned for, to be held August 15-19. About one hundred invited guests, members and friends of the association will compose the party. David Gill, Astronomer Royal of the Observatory at Cape of Good Hope is chairman of the committee of arrangements. In a two-column article in the *Times*, Dr. Gill gives full particulars of this unusual meeting of scientists. He says: "The event is unique in the history of science. Never before has so large and influential a body of scientific men crossed the equator and met together for the purpose of promoting science in the southern hemisphere."

The list of names published in this article embraces the names of some of the most noted scholars in every department of science. The itinerary planned for covers a period of seventy days. It includes many of the prominent places in South Africa.

The Solar Origin of Terrestrial Magnetic Disturbances.—The paper on the above subject by Mr. E. W. Maunder in the February number of POPULAR ASTRONOMY calls for a few words of explanation, for I do not find therein any reference to the fact that I announced more than a quarter of a century ago, that the solar action producing terrestrial magnetic disturbances is restricted to limited areas of the Sun's surface, and also that the action does not radiate in all directions like light and heat, but along restricted meridians. There is a reference to *one phase* of my *first* results in the later editions of Professor C. A. Young's work "The Sun"; but I am now preparing a connected account of my results in this investigation, which I hope to publish very shortly.

VANCOUVER B. C. T. S. H. SHEARMAN.

Dr. Arthur A. Rambut of the Radcliffe Observatory, Oxford, England, has prepared and communicated to *Monthly Notices* November 1904, an article giving a very sensitive method of determining the irregularities of a pivot. The method has been applied to the pivot errors of the Radcliffe transit circle, and their effect on the right ascensions of the Radcliffe Catalogue of 1890 is really surprising. In a table on page 78 of the article will be seen that in almost every case where the correction for pivot error amounts to as much as 0ˢ.01, it is of opposite sign to the corresponding difference of right ascension. North

of the zenith the correction is too large and more than cancels these differences, while on the other side of the zenith, and down to about 5° south of the equator, the correction is too small. From north polar distance 95° down to 120° the corrections almost exactly account for the marked differences between the Radcliffe 1890 and Stone 1880, while the differences Radcliffe-Greenwich are largely reduced.

The thorough and complete way in which this paper is worked out with half-tone illustrations, numerous cuts and colored graphs, makes it one of exceptional interest for astronomers engaged in meridian circle work.

Radio-Activity in General—In the March number of the *Journal of the Franklin Institute* occurs an interesting article about "Radium and Radio-Activity in General." The points discussed are the atomic theory, the atom an unalterable existence, the radium rays, corpuscles α-, β- and γ-rays, and their effects, the radium emanation, excited or secondary radio-activity, the radio-active process in comparison to ordinary chemical changes, its uncontrollable character, enormous amount of energy evolved, radio-activity in general, thorium, radio-activity of ordinary substances, the evolution of matter.

This thoughtful article was prepared by Robert T. Bradbury. A fuller idea of its scope and insight may be gained by reading its closing paragraphs in his own words as follows:

"Thus the atom of radium contains an enormous supply of energy which is gradually liberated, and this liberation is coincident with a number of successive transformations of the substance which end in the production of helium. Several other elements are known which exhibit similar phenomena, but in a much less intense degree. The radio-activity of *thorium* has been carefully studied by Rutherford. In general character it is quite similar to that of radium. There is a *thorium emanation* which is intensely radio-active, which is transformed into a solid. This solid attaches itself to the surfaces of bodies and makes them temporarily radio-active, and so on. The chief difference is that in the case of thorium the changes take place about 1,000,000 times more slowly. This means that, if we imagine a quantity of radium and a quantity of thorium weighed off so as to contain the same number of atoms, about 1,000,000 times as many atoms would explode per second in the radium as in the thorium. It has been shown that, given a quantity of pure radium to start with, $\frac{1}{2000}$ of it would disintegrate per year. In 10,000 years practically all of it would have run its course. The rate of change of thorium is approximately given by multiplying both of these periods by 1,000,000. But the total energy given off is probably of the same order in the two cases. It is only the speed which is different.

"Are the atoms of all matter similarly constituted? Is radio-active change constantly taking place in ordinary matter? Are radium, thorium and the rest of the radio-active elements simply those in which the number of atoms which disintegrate per second is so large that the process is easily detected? These are far-reaching questions. The obvious way of getting an answer to them is to test ordinary matter, like silver, platinum, copper, and so on, for radio-activity. Strutt has done this with great care, and his result is that all ordinary substances appear to possess a slight radio-activity. Unless this is due to a faint trace of a radio-element, it opens a vista of thought which staggers the imagination. A slow—inconceivably slow—process of evolution is taking place in the matter around us. Billions of times more slowly than radium, the elements are changing into something else. Matter has had a beginning and will have an end. So much we can see, but the beginning and end may remain forever unknown to us."

Ives Replicas of Rowland's Diffraction Gratings.—We notice that a new process of reproducing Rowland's spectroscope gratings has been advertised which is designated as Ives New Process Replicas of Rowland's Diffraction Gratings. It is claimed by the author of this new method that Thorp's way of reproduction by making a celluloid cast and mounting the same on glass makes copies good for some purposes, but thus such a film always distorts sufficiently to mar definition more or less, so that the best of them do not define equally well over their entire surfaces. If this is true, serious results will follow in several ways, as may be early imagined by any one understanding the principles of the diffraction grating.

The improvement by the Ives method is effected by making the casts of harder and less elastic material than celluloid, by putting them face down upon the glass and forcing them into optical contact therewith, so that the perfect plane of the diffracting surface is preserved, and by sealing them up under another plane glass with a balsam mixture having the same refraction index as the casting material, so that the perfect parallelism of the transmitted rays is insured, and at the same time the grating is protected from injury.

These gratings that are copies made from those of Rowland that are considered as A in quality are sold at one fifth the cost of quality A originals. As an example of these copies one may be cited. It is said to have about 15,050 lines to the inch, has nearly one square inch of ruled surface in a block of glass one and one-half inches by two and one-fourth inches. This copy is recommended only for use in students' spectroscopes having not more than one inch of aperture. It is guaranteed to show distinctly the nickel line between D_1, D_2 and the D lines themselves sharply defined and black with direct sunlight, either in first or second order spectra. Other interesting points of favor are claimed for replicas by this new process.

The Earth Flat and Floating in Water.—In the "Inter Ocean" of March 5, more than one-half of page 7, is devoted to a description of a theory by one C. F. Hathaway in an endeavor to prove that the Earth is flat. He also believes that there is no such thing as gravitation and that the Earth floats in water, but neither of these statements are proved or is there any attempt to prove them. He disputes the curvature of the Earth as proved by science for the last hundred years, because he can not repeat the experiments. He has been to England to the places where some experiments have been made that are matter of science and history and he disputes the facts.

He need not have gone to England to get proofs of the Earth's curvature. If he had observed the shadow of the Earth near any clear sunset or sunrise time, he could have had a better proof than any he has attempted to give to show the contrary. If he had ever observed a partial eclipse of the Moon, and understood the meaning of the dark shadow on it, he would have something pretty hard to explain by his flat theory of the Earth's surface. We were interested in his exact knowledge of the size and distance of the Sun. He says it is exactly 32 miles in diameter and that its distance is 3,000 statute miles above the Earth." It would interest the scientific world to know just how he has obtained these very important data. It has been a long time since we have seen in so reputable a paper as the *Inter Ocean* such a mess of nonsense as this. We have thought of this paper as the very best of the Chicago dailies, in most respects, because people could always find in it things to read that were instructive and worth their time in so doing many times over.

It might be well for the management of the noble paper to consider the advisability of employing a competent science editor very soon.

Mathematical Progress in America.—As the progress in astronomy in this country, or probably in any other, depends very largely upon the progress in the study of mathematics, it has always been our aim to keep the two pursuits in near relation to each other in conducting this magazine, so that all the advantages accruing to the one may be made fully and immediately helpful to the other as far as possible.

At present the great activity in this country in the study of pure mathematics is securing wide attention. In a recent address by Thomas S. Fiske on the progress of mathematics in America, he calls attention to the needs now apparent that progress in the future may be more satisfactory. He says:

"In the first place the most pressing demand seems to be that those engaged in lecturing on the more advanced branches of mathematics in American universities should be given greater opportunities for private study and research. At present, the time of almost every university professor is taken up, to a very large extent, with administrative matters connected with the care of comparatively young students. Discussion in regard to admission requirements, the course of study, discipline, and the control of athletics, absorb a large part of the time and strength of the faculty of every university. It is possible that this situation will in the course of the next twenty years be greatly relieved by a change, which many consider is already in sight. This change is nothing more or less than the relegation of the first two years of the ordinary college course, to the secondary schools and the establishment of university courses that will begin with the present third year of the college. The progress made in recent years by the public high schools makes it plain that before long they will be able, without difficulty, to duplicate the first two years in the present college course, and as more highly trained teachers enter these schools there is no doubt that there will be a constantly increasing effort to take up college work. If this is done, not only will the condition of the secondary schools be greatly improved, but our university teachers will secure the relief so greatly needed for the advancement of the highest interests of our science."

The author of this interesting paragraph also mentions three other needs. First, that there should be encouragement given to the strong mathematical journals already in existence in this country. Second, improved methods of teaching, better text-books and more good treatises on advanced subjects, and third the organization and maintenance of mathematical societies, for exchange of views and discussion of themes of common interest to the progress of mathematical science.

It must be admitted by every candid scholar that these points, every one, are of prime importance. For two years past the movement to change the ordinary college course has been discussed in all parts of this country. Every grade of school in our American system is interested in it and will be powerfully effected by it. The changes suggested in this address are so radical and so far reaching in assumption that we greatly fear its author has not well considered the probable results that will follow if they are made.

Different Methods of Determining Longitudes on Jupiter.—A. Stanley Williams in *Monthly Notices* of the Royal Astronomical Society has written an extended article on the relative efficiency of different methods of determining longitudes on Jupiter. Mr. Williams considers this important matter pretty thoroughly and he takes issue with Professor Hough of Dearborn Observatory on some points. Those interested in the work of the micrometer as a means of measuring markings on the surface of Jupiter should read the articles by both these astronomers in *Monthly Notices* Vol. 64, No. 9, and Vol. 65, No. 2

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